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Report No. CG-D-76-78 LEVEL II VOLUME I OF IV

FUNCTIONAL JOB ANALYSIS OF MOBILE OFFSHORE DRILLING UNIT OPERATIONS

VOLUME I:

SUMMARY REPORT

APRIL 1978

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16. Abstract

This report is the product of a 2-year study of mobile offshore drilling unit (MODU) operations. The study was performed for the U.S. Coast Guard to provide a basis for establishing marine-related qualifications requirements for MODU personnel.

Functional Job Analysis (FJA) was used to prepare detailed, standardized descriptions of the tasks required under routine and emergency conditions, taking into account MODU design and equipment, availability of personnel, and environmental variables. The study addressed all five design types of MODU: drill ships, floating drill barges, submersibles, semisubmersibles, and self-elevating units. Four modes of operation were analyzed: the underway mode (moves to/from the drilling site), the transition from underway status to drilling status, the drilling mode, and the emergency mode (including four specific emergency conditions). The functional area of onboard personnel supervision and training is treated separately. Industry practices in the selection and training of personnel were reviewed for comparison with the experience and training needs indicated by the analysis.

The report is presented in four volumes, the first of which provides background descriptions of MODU characteristics and operations, a summary of the results, and the recommendations made by the study team. Volumes II and III contain the task data. Volume IV is an appendix of supporting materials.

17. Key Words	18. Distribution Statement
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The work of the study team was facilitated both by U.S. Coast Guard personnel and members of the offshore drilling industry. A complete list with acknowledgments of specific contributions would be very long indeed. Regretfully, we cannot fully acknowledge all contributions here.

The Coast Guard officials who provided information, reviewed materials prepared by the study team, assisted in procedural and contractual matters include

- RADM William M. Benkert, Chief of the Office of Merchant Marine Safety
- CDR Keith P. Pensom, Office of Merchant Marine Safety, who monitored this study throughout
- Dr. John S. Gardenier, Office of Research and Development, who was the Contracting Officer's Technical Representative for the first phase of the study
- Mr. Todd Jones, Office of Research and Development, the Contracting Officer's Technical Representative for the second phase of the study
- Mr. R.L. Twilley, Chief of the Research and Development Contract Branch, Office of Comptroller
- Mr. Ted Higgs, Research and Development Branch, Office of Comptroller, who was responsible for contractual matters day-to-day
- CDR Daniel F. Bobeck, Chief, Merchant Marine Technical Branch, 8th Coast Guard District
- CDR P.J. Cronk, Offshore Operations Liaison Officer, 8th Coast Guard District.

The study could not have been completed as it was without extensive cooperation and assistance from the industry itself. The individual companies that provided information, gave time to reviewing the task data and other materials, and hosted the study team on visits to their MODUs, are listed in the Summary Report (page 9). We are most grateful for their concern, time and effort spent, and exceptionally constructive comments.

The coordination and assistance provided by the International Association of Drilling Contractors (IADC) is also gratefully acknowledged. In particular we would like to thank

- Mr. I.J. Flowers, Chairman of the IADC Offshore Committee and Vice President, Marine Operations, Santa Fe Drilling Company
- Mr. Ed McGhee, IADC Executive Vice President.

Mr. Lejeune Wilson, Vice President for Personnel and Training, SEDCO, Inc., was chairman of the IADC committee who reviewed the study results in phase two and whose members graciously met with study team representatives for a meeting hosted by Zapata Offshore Company in Houston for the purpose of discussing results. Those who participated in the meeting include

- Global Marine Inc. - Mr. John Duke
- IADC - Mr. Jon Bednerik, Mr. Ed McGhee, and Mr. George Williford
- Penrod Drilling Company - Mr. Marshall Ballard
- ODECO - Mr. Charles S. Howe
- Transworld Drilling Company - Mr. Marvin Bender, Mr. John W. Cox, and Mr. John Gillespie
- Western Oceanic - Mr. Mike Patton
- Zapata Offshore Company - Mr. David R. King and Mr. Andrew Stohrer.

DOCUMENT ORGANIZATION

This report has four volumes. The first is called the Summary Report. It addresses all five types of mobile offshore drilling unit (MODU) whose operations were studied in this project. Specifically, it includes

- Statement of the study purpose and scope
- Review of the method
- Background description of the types of MODU with discussion of similarities and differences and the effects of design type on operational requirements
- A review of operational hazards related to casualty data
- Overview of MODU personnel organization and the task activities and responsibilities of different categories of personnel
- Review of current practice in the offshore drilling industry regarding personnel experience and training
- Conclusions and recommendations regarding the training and experience needs of MODU personnel, taking into account current practice.

Volume II contains individual reports on the five types of MODU. Those reports provide additional background information and then focus on training needs. They contain

- Summary tables of training needs in each functional area of MODU operations in which there are differences associated with MODU type. Those tables distinguish activities and responsibilities of supervisory and lower-level personnel.

5

- The detailed task analysis sheets for those functional areas in which variation in task requirements is associated with MODU type. (The task analysis sheets comprise a data base that is the basic output of the study.)

Volume III is the equivalent of Volume II for those functional areas in which there is little or no variation in task requirements associated with MODU type. Volume III also contains

- Summary tables categorizing training needs for supervisory and lower-level personnel

- Detailed task analysis sheets for the subject functional areas.

An appendix is provided, including bibliography, more detailed description of the method of task analysis (Functional Job Analysis) used in this study, and lists of courses and schools currently available for offshore drilling personnel.

TABLE OF CONTENTS

SUMMARY REPORT

LIST OF FIGURES

Page

8

LIST OF TABLES

9

SUMMARY REPORT

This report describes a study performed for the U.S. Coast Guard, Office of Merchant Marine Safety, under the provisions of Contract DOT-CG-41903-A, Task Order IV-B. The study was done by ORI with subcontractor Engineering Computer Optecnomics (ECO), Inc. It was completed in two phases, totaling about 13 months, during 1976 and 1977.

STUDY PURPOSE

The study was designed to assist the Coast Guard in ensuring that personnel who work aboard mobile offshore drilling units (MODUs) are suitably trained and experienced for the marine-related functions in MODU operations. The purpose of investigating those qualification needs is to prevent or minimize loss of life, injury, property damage and ecological damage resulting from petroleum operations in the offshore waters of the United States.

NATURE AND SCOPE OF THE STUDY

The study involved analysis and documentation of the tasks required in MODU operations. Personnel training and experience needs were drawn from the task specifications. Personnel selection and training practices in the U.S. drilling industry were considered in light of the analysis results. Recommendations were made concerning marine-related training and experience requirements.

We documented only the tasks performed by employees of the drilling contractor, the company that operates and in most cases owns the MODU. The lease operator (an oil company) also has personnel on board the MODU during some or all stages of the operations (e.g., drilling engineer, mud engineer, geologist). In addition, various specialists come on board as needed to perform such jobs as cementing, well logging, and diving. The specialists are normally hired by the lease operator, just like the drilling contractor. The work of those personnel was not within the scope of this study.

Definition of "Marine-Related"

"Marine-related" was broadly defined by the Coast Guard for this study to include all functions that either involve or affect the following aspects of marine safety:

- "Preparation for getting underway or for stopping a mobile unit
- Navigating such a unit
- Maintaining a stable position and/or orientation of a unit in a seaway or waterway, whether or not the unit is underway
- All emergency response actions when the unit is in a seaway or waterway."

Industrial functions were included in the analysis because it is not possible to understand the requirements for marine safety without understanding the overall operations. A MODU is a single operating entity—a marine industrial facility that moves periodically as a vessel would. The marine requirements are largely affected by the industrial nature of a MODU. The reverse is true as well, although to a lesser degree. These thoughts are elaborated in the conclusions and recommendations presented later.

MODU Functions Examined

The final set of functions examined in the analysis includes:

- Navigation to/from the drilling site
- Positioning the unit and making ready to engage or disengage drilling equipment (the transition between underway operations and drilling operations and the reverse).
- Position-keeping at the drilling site (for floating units)
- Operation and maintenance of the power plant
- Transfer operations between the MODU and offshore supply vessels
- Drilling operations
- Maintenance of drilling systems and equipment
- Emergency response
- Personnel training and supervision.

Types of MODU

The analysis was done for five types of MODUs:

- Self-elevating units, or jackups
- Submersibles
- Semisubmersibles
- Drill ships
- Floating drill barges.

LIMITATIONS

The analysis results are generalized to be applicable to different MODUs under different conditions. There are substantial similarities in the work done. However, differences in size, particular design features, equipment, the complement of personnel and their characteristics, and individual company policies all affect the tasks performed and by whom they are performed. So do the nature of the formation being drilled, water depth, wind-wave conditions, and other factors. The study results are not presented as a definitive set of operating procedures. Rather, the results describe the types of tasks that are required, the types of conditions to which MODU personnel must respond, and the types of skills, knowledge, and experience they need to work effectively under their various specific circumstances. Each unit and each drilling job is unique in a number of respects. We have attempted to convey that in the analysis results.

PRECEDENTS

ORI and ECO have performed analyses of several marine work systems for the U.S. Coast Guard. We have studied the operations of tankers, towboat-barge arrays, nuclear-powered ships, liquefied natural gas carriers, and hazardous chemical carriers, as well as the different types of mobile units used in offshore exploratory drilling. The list below indicates the types of problems which these studies have addressed:

• Hazardous cargo handling in marine transport • Commercial nuclear ship propulsion	New technology personnel requirements (selection and training criteria)
• Vessel control	Operations safety focus (avoidance of collisions, rammings, groundings)

METHOD

The method used is Functional Job Analysis (FJA), developed by Sidney A Fine.[1] FJA is a method of task analysis that is designed to maintain a system perspective on work requirements:

- In FJA, task analysis begins with delineation of the functional requirements--the purpose, goals, and objectives of the work organization.
- FJA requires identification of the resources and constraints (such as equipment and materials, operating conditions, hazards, and regulations) that affect how the system can fulfill its functional requirements.
- FJA then describes the actions--tasks--through which the requirements are fulfilled in light of the resources and constraints.
- Performance standards are established for each task, reflecting its complexity and its criticality in the sense of impact on system viability.
- Training requirements are derived from the stated task requirements.

The task is the fundamental unit of work to which the analysis is directed (as opposed to the job category). Tasks arise from the work system functions (stated as purpose, goals, and objectives in FJA). Tasks are examined in relation to the resources and constraints of the work system. The capacities, skills, and knowledge needed by personnel are deduced from, and expressed in relation to the functional goals and objectives of the system and the resources and constraints.

Figure S.1 illustrates the task analysis structure for an example case. The figure includes the MODU functions previously listed, which are called goals in the terminology of FJA. Those functions, or goals, are broken down into objectives and tasks. Each level of the functional taxonomy provides more detailed information about what is done.

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[1] See, for example, S. Fine, A. Holt, and M. Hutchinson, Functional Job Analysis: How to Standardize Task Statements, Methods for Manpower Analysis, No. 9, W.E. Upjohn Institute for Employment Research, Washington, D.C., October 1974; S. Fine, Functional Job Analysis: An Approach to a Technology for Manpower Planning, W.E. Upjohn Institute for Employment Research, Washington, D.C., February 1973; ORI, Inc., Functional Job Analysis of Mobile Offshore Drilling Unit Operations, Vol. IV: Appendix, Silver Spring, Md., October 1974; ORI, Inc., Handbook for the Development of Qualifications for Personnel in New Technology Systems, Silver Spring, Md., June 1976.

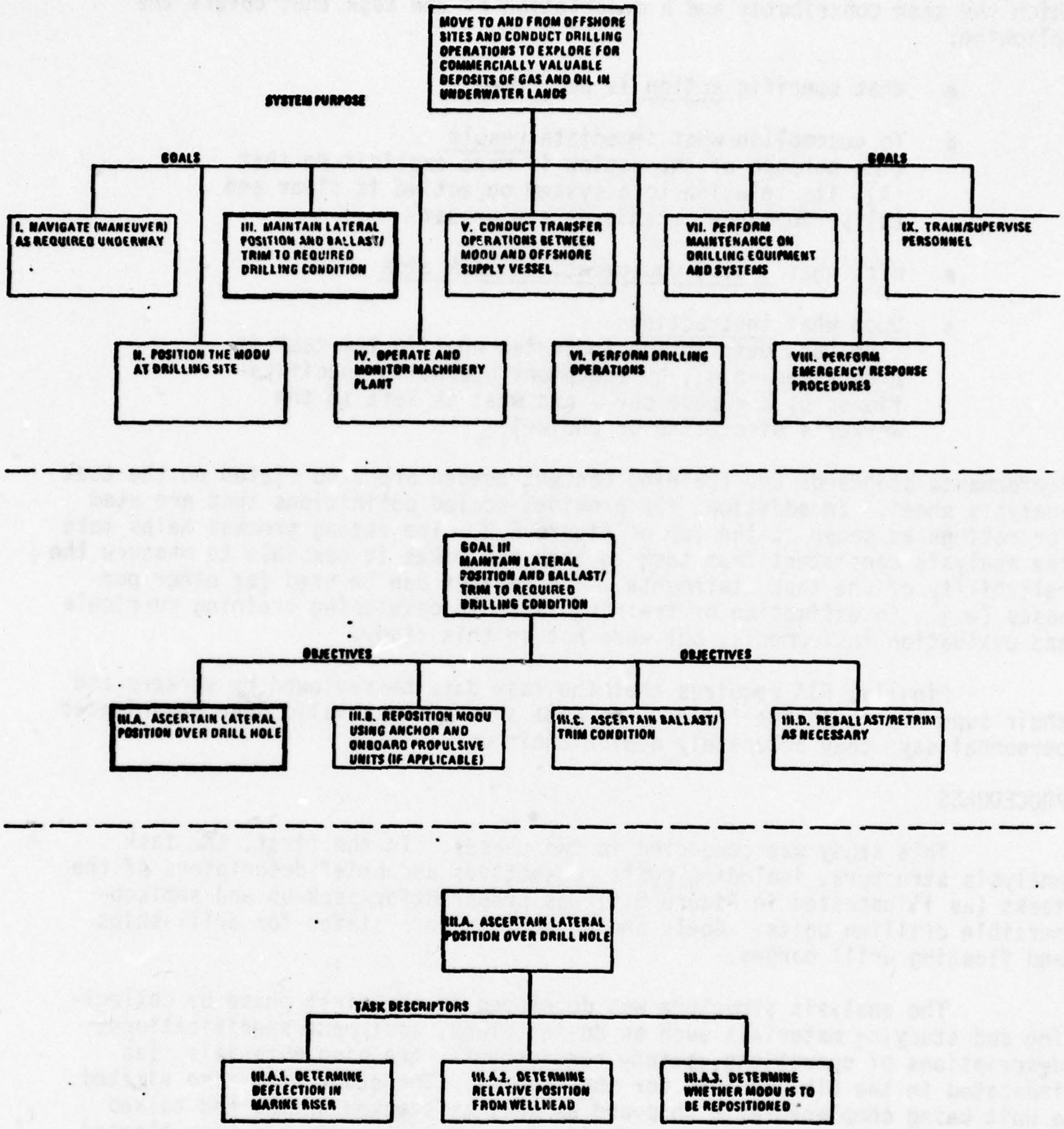

FIGURE S.1. PARTIAL TAXONOMY OF GOALS, OBJECTIVES, AND TASKS OF MODU OPERATION

(Example case: Units that remain afloat while drilling)

Figure S.2 is an example of the basic output from FJA, a complete task analysis sheet. As shown, the sheet includes the goal and objective to which the task contributes and a description of the task that covers the following:

- What specific action is performed

- To accomplish what immediate result
(The purpose of the action is made explicit so that (1) its relation to a system objective is clear and (2) performance standards can be set)

- With what tools, equipment, or work aids

- Upon what instructions
(The task description indicates what in the task is prescribed--e.g., by equipment operating specifications, by a supervisor-- and what is left to the worker's discretion or choice).

Performance standards and training content needed are also stated on the task analysis sheet. In addition, FJA provides scaled definitions that are used for ratings as shown at the top of Figure S.2. The rating process helps make the analysis consistent from task to task and makes it possible to measure the reliability of the task statements. The ratings can be used for other purposes (e.g., in estimation of training time, in developing training curricula and evaluation instruments) but were not in this study.

Finally, FJA requires that the task data be reviewed by workers and their supervisors in the field. The data are taken as valid when experienced personnel say they accurately depict their work.

PROCEDURES

This study was conducted in two phases. In the first, the task analysis structure, including goals, objectives and brief descriptors of the tasks (as illustrated in Figure S.1) was prepared for jack-up and semisubmersible drilling units. Goals and objectives were stated for drill ships and floating drill barges.

The analysis structure was developed in the first phase by collecting and studying materials such as design plans, equipment specifications, descriptions of operations, safety requirements, training materials (as indicated in the bibliography for the report). The study team also visited a unit being completed at a shipyard as well as stacked units, and talked with personnel in the industry. Visits to operating units had been planned but could not be made because of difficulty in obtaining required insurance coverage.

TASK CODE: JU-I.D.1

WORKER FUNCTION LEVEL AND ORIENTATION						WORKER INSTRUCTIONS	GENERAL EDUCATIONAL DEVELOPMENT		
DATA	%	PEOPLE	%	THINGS	%		REASONING	MATH	LANGUAGE
4	65	1A	5	2B	30	4	4	3	4

TASK CODE: JU-I.D.1 **GOAL:** Navigate (maneuver) as required underway.

OBJECTIVE: Furnish propulsion assistance with onboard units while being towed.

TASK: Determines the weight, longitudinal (LCG), vertical (VCG), and transverse (TCG) centers of gravity for the MODU and determines necessary adjustments in order to assure that MODU is in satisfactory stability condition according to MODU's trim and stability booklet by measuring the weight, LCG, VCG, and TCG for all items on the MODU and following the prescribed procedure to calculate those values for the entire MODU.

PERFORMANCE STANDARDS	TRAINING CONTENT
<u>Descriptive:</u> • Accurately determines weight, LCG, VCG, and TCG for all items on the MODU. • Precisely calculates weight, LCG, VCG, and TCG for the entire MODU. • Precisely adjusts weight, LCG, VCG, and TCG to within allowable limits according to MODU's trim and stability booklet. <u>Numerical/Categorical:</u> • Weight, LCG, VCG, and TCG are within, or adjusted within, allowable limits.	<u>Functional:</u> • How to determine the weight, LCG, VCG, and TCG for all items on the MODU. • How to calculate the weight, LCG, VCG, and TCG for the entire MODU. • How to adjust weight, LCG, VCG, and TCG to allowable limits. <u>Specific:</u> • Knowledge of location of all consumable items on the particular MODU. • Knowledge of the method of calculating the weight, LCG, VCG, and TCG of items on the particular MODU. • Knowledge of required/allowable weight, LCG, VCG, and TCG of the particular MODU and familiarity with trim and stability booklet contents. • Knowledge of the effect of excessive situations on the stability and handling of the particular MODU.

FIGURE S.2. EXAMPLE OF THE BASIC TASK ANALYSIS OUTPUTS

Through the cooperation of the International Association of Drilling Contractors (IADC), members of the industry reviewed and critiqued the analysis structure and the background information presented in the Phase I report.

In the second phase of the study, the analysis structure was completed for drill ships, barges, and submersible drilling units in the same way as it was done for the two other MODU types in the first phase. Visits to operating MODUs were accomplished through the cooperation of five companies. The complete task analysis sheets were prepared based on observation and information from operating personnel, as well as written sources.

The final step in the study was industry review, again accomplished through the IADC, which set up a committee including representatives of eight drilling contractors.

The contractors who assisted the study team in making visits to operating units, contributed to the reviews, or both, are listed below:

- <u>Review, Phase I</u>
  - Ocean Drilling & Exploration Co. (ODECO), Inc.
  - Santa Fe Drilling Company
  - Zapata Off-Shore Company

  (Others were invited to review but gave no comments.)

- <u>MODU Visits</u>
  - Global Marine Inc.
  - ODECO, Inc.
  - Santa Fe Drilling Company
  - Transworld Drilling Co.
  - Zapata Off-Shore Company

- <u>Review, Phase 2</u>
  - Global Marine Inc.
  - Key International
  - ODECO, Inc.
  - Penrod Drilling Co.
  - Santa Fe Drilling Company
  - SEDCO, Inc.
  - Transworld Drilling Company
  - Western Oceanic
  - Zapata Off-Shore Company.

The names of these companies are listed in recognition of the fact that they were willing to provide information; to lend their expertise in reviewing and commenting on the work done by the study team; and, in some cases, to permit the study team to observe operations and survey personnel on their drilling units. This cooperation drew upon company time and resources, particularly in the case of visits, and it is acknowledged with appreciation.

NUMBERS AND OPERATING AREAS OF MODUs

As of September 1977, there were 440 MODUs in existence, and 31 additional units under construction or ordered. Jackup drilling units predominate, with the semisubmersible design type second most numerous. Table S.1 gives a breakdown by type and operating area worldwide.

TABLE S.1

WORLDWIDE OFFSHORE MOBILE DRILLING ACTIVITY
(Source: Offshore Rig Data Services, Houston, Texas, "The Offshore Rig Location Report," September 1977)

Area of the World	Number of Units by Type										Total	
	Submersibles		Semisubmersibles		Jackups		Ships		Barges[1]			
	W	NW	W	NW	W	NW	W	NW	W	NW	Working	Not Working[2]
Arctic Area & Alaska	0	0	4	0	0	0	3	0	0	0	7	0
Pacific Coast	0	0	1	3	0	0	3	2	1	0	5	5
E. Canada & Greenland	0	0	1	0	1	0	2	0	0	0	4	0
Great Lakes	0	0	0	0	3	0	0	0	2	0	5	0
U.S. East Coast	0	0	0	1	0	0	0	0	0	0	0	1
Gulf of Mexico - U.S.												
Miss., Ala., Fla.	0	0	0	0	1	0	0	1	0	0	1	1
Louisiana	15	0	18	0	48	0	3	1	0	1	84	2
Texas	1	0	4	0	14	0	3	2	0	0	22	2
Gulf of Mexico - Mexico	0	0	0	1	2	0	0	0	2	1	4	2
Caribbean & Central America	0	0	2	0	2	0	0	1	0	0	4	1
South America												
Lake Maracaibo	0	0	0	0	3	0	0	0	12	0	15	0
Brazil	0	0	7	0	11	0	2	0	0	0	20	0
Other	0	0	1	0	1	0	0	1	0	0	2	1
Europe - North Sea	0	0	45	3	14	1	1	0	0	0	60	4
Europe - Other	0	0	3	1	2	0	1	1	0	0	6	2
Mediterranean Area	0	0	6	2	3	2	7	2	1	1	17	7
West Africa	1	0	0	0	7	1	2	0	1	0	11	1
South & East Africa	0	0	1	0	0	0	0	0	0	0	1	0
Red Sea & Gulf of Suez	0	0	1	0	7	1	2	1	0	0	10	2
Arabian/Persian Gulf	0	0	0	0	27	3	0	1	0	0	27	4
Pakistan, India & Indochina	0	0	1	0	2	0	0	2	1	0	4	2
Southeast Asia	0	0	3	0	6	1	3	6	1	6	13	13
Far East	0	0	2	3	6	0	3	0	0	0	11	3
U.S.S.R.	0	0	0	0	5	1	0	0	0	0	5	1
Australia & Oceania	0	0	1	3	0	1	1	0	0	0	2	4
TOTAL	17	0	101	17	165	11	36	21	21	9	345	58
											(Without contracts)	37

[1] Does not include international inland barges (10).
[2] W = working; NW = not working. Not working means rig is idle, in port for repairs, final outfitting, or in tow from one body of water to another. Rigs moving from one location to another in the same body of water are considered working.

As Table S.1 indicates, the majority of MODUs, more than two-thirds, are operating overseas. Presently (as of September 1977), a total of 125 MODUs are located offshore the continental United States and Alaska, including eight not working, one engaged in salvage operations, and several engaged in well workover or completion, rather than drilling. Table S.2 shows the numbers by more specific location and type. No floating drill barge worked offshore the United States in 1976-1977.

TABLE S.2

MODUs OFFSHORE THE CONTINENTAL UNITED STATES AND ALASKA
(Source: Offshore Rig Data Services, Houston, Texas, "The Offshore Rig Location Report," September 1977)

Area	Number of Units by Type				Total
	Submersibles	Semisubmersibles	Jackups	Ships	
Alaska	0	4	0	0	4
Pacific Coast	0	4	0	5	9
East Coast	0	1	0	0	1
Gulf of Mexico	16	22	63	10	111
Total	16	31	63	15	125

DESCRIPTION OF MODU DESIGN TYPES

Jackups

Figure S.3 shows a jackup drilling unit. The distinctive feature of this design type is the legs. When the unit is afloat, the legs can be lowered to stand on the sea floor and support the unit. When the legs are on bottom the platform can be raised on them to clear the water surface with the desired air gap or lowered to float again. Jacking systems have hydraulic pin or electric rack and pinion drives.

Leg length determines the depth of water in which the unit can operate. The upper limit is about 400 feet. The legs may be cylindrical or open-fabricated. Open fabrication permits greater leg strength without increasing wave force. Some units have canted legs to decrease bending moment and increase stability. These innovations resulted from the impetus for deeper water drilling.

To counteract excessive leg penetration in soft soils, legs are fitted at the lower ends with spud cans and/or stand on a movable mat-type hull.

Most jackups have three or four legs, but units with as many as 14 have been built. Platform shape also varies, with square, triangular, and multisided platforms all common.

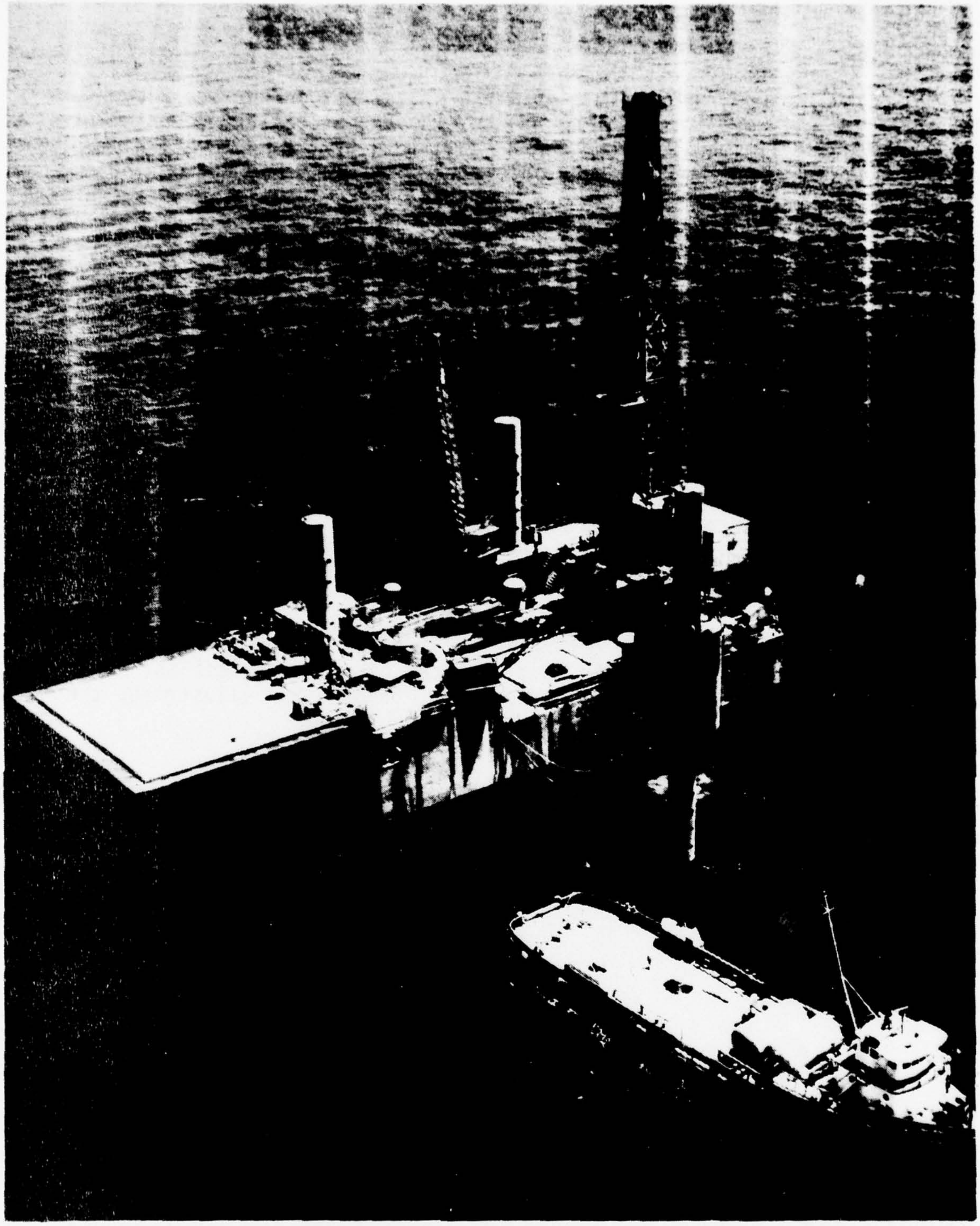

FIGURE S.3. ILLUSTRATION OF A JACKUP MODU
(Courtesy of Transworld Drilling Company, Oklahoma City, Oklahoma)

Submersibles

Like jackups, submersible drilling units rest on the sea floor for drilling, but they are set in place by the flooding of ballast compartments. Submersibles are limited in water depth capability by the depth to which platforms can feasibly be built. The usual water depth range is between 30 and 70 feet. Only one submersible unit is capable of drilling in water deeper than 80 feet. (Transworld's RIG 54, the largest unit of this type, can drill in water up to 175 feet deep with a deck clearance of 25 feet.)

The submersible is the oldest type of mobile offshore drilling unit, evolving through a number of design changes from the posted inland drill barges that worked in protected waters not over 10 feet deep. One of the early designs, still in use, has movable pontoons that remain on the surface while the hull is set and then are lowered to reduce the effects of wave forces on the submerged hull. Submersibles today are typically column-stabilized. Large-diameter vertical columns ("bottles"), connected by cross members, run between the platform and lower hull.

Mud skirts around the hull periphery are used to minimize lateral movement induced by wave action and the scouring of soil from around the hull; this is particularly common on units operating in soft-bottom areas. Some units use spuds for lateral support.

Early units had long rectangular platforms. Later, a platform more nearly square was introduced—the shape typical of semisubmersibles. The platform of the largest submersible is triangular. Figure S.4 illustrates the bottle-type submersible design.

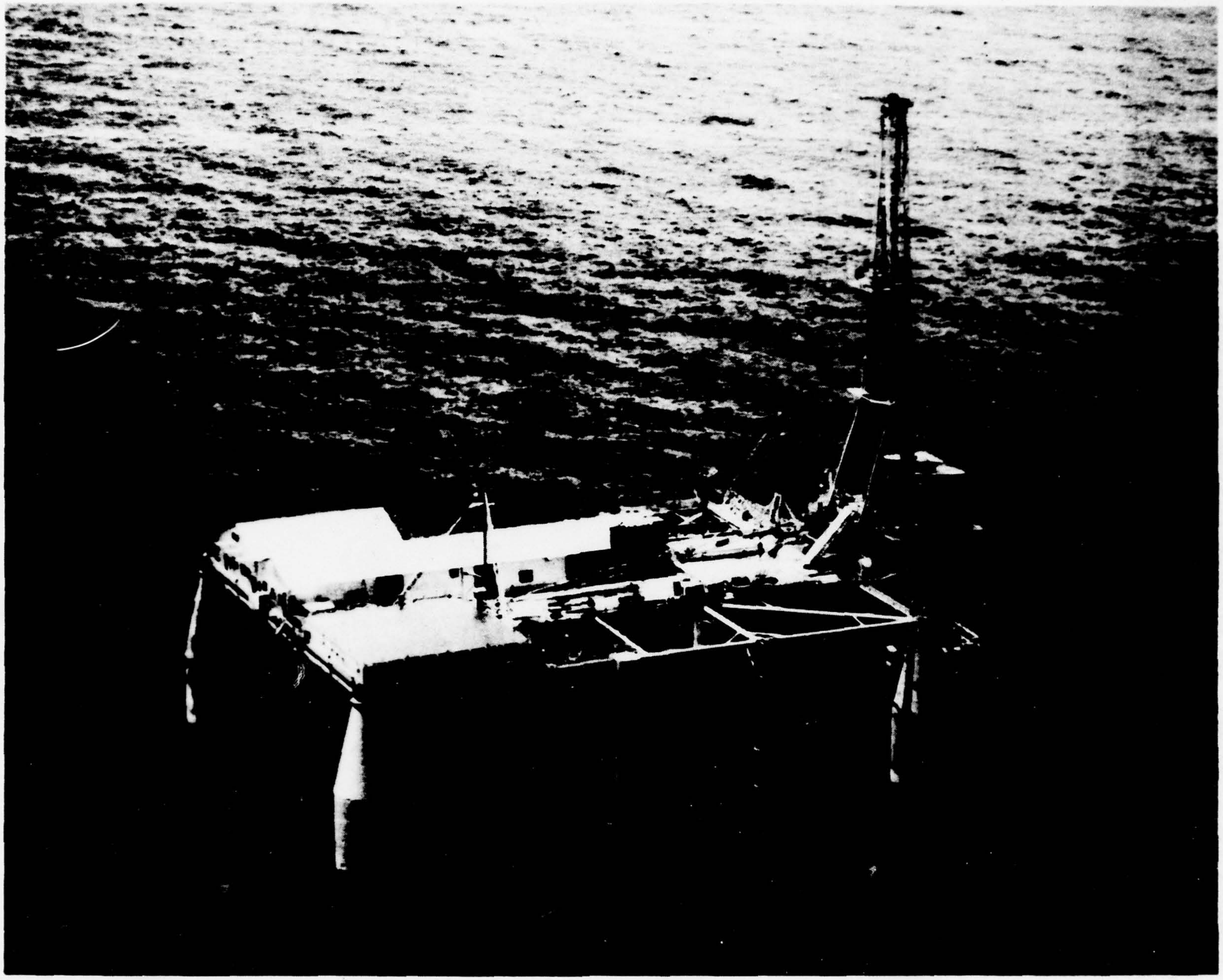

FIGURE S.4. ILLUSTRATION OF A SUBMERSIBLE MODU
(Courtesy of Transworld Drilling Company, Oklahoma City, Oklahoma)

Semisubmersibles

Semisubmersibles are column-stabilized units that float for drilling with their major buoyancy members submerged below the most severe wave action. This gives them great stability and reduces position-keeping problems. Thus the semisubmersible design is generally considered to be the most suitable for drilling in rough water areas (although innovations in drill ship mooring and positioning technology are making it possible for the ships also to work in heavy seas).

As illustrated in Figure S.5, the platform rests on large vertical columns, caissons, or a combination of the two, connected to large underwater displacement hulls. Those members are flooded to submerge the unit partially to drilling draft. Semisubmersibles have also been used as bottom-sitters for drilling in relatively shallow water.

Most semisubmersibles are square or rectangular in shape, but some are triangular or multisided. The derrick is usually located at the center of buoyancy to reduce trimming problems caused by the large variable hook loads in drilling. A spread mooring pattern is used to hold the unit on location in most cases.

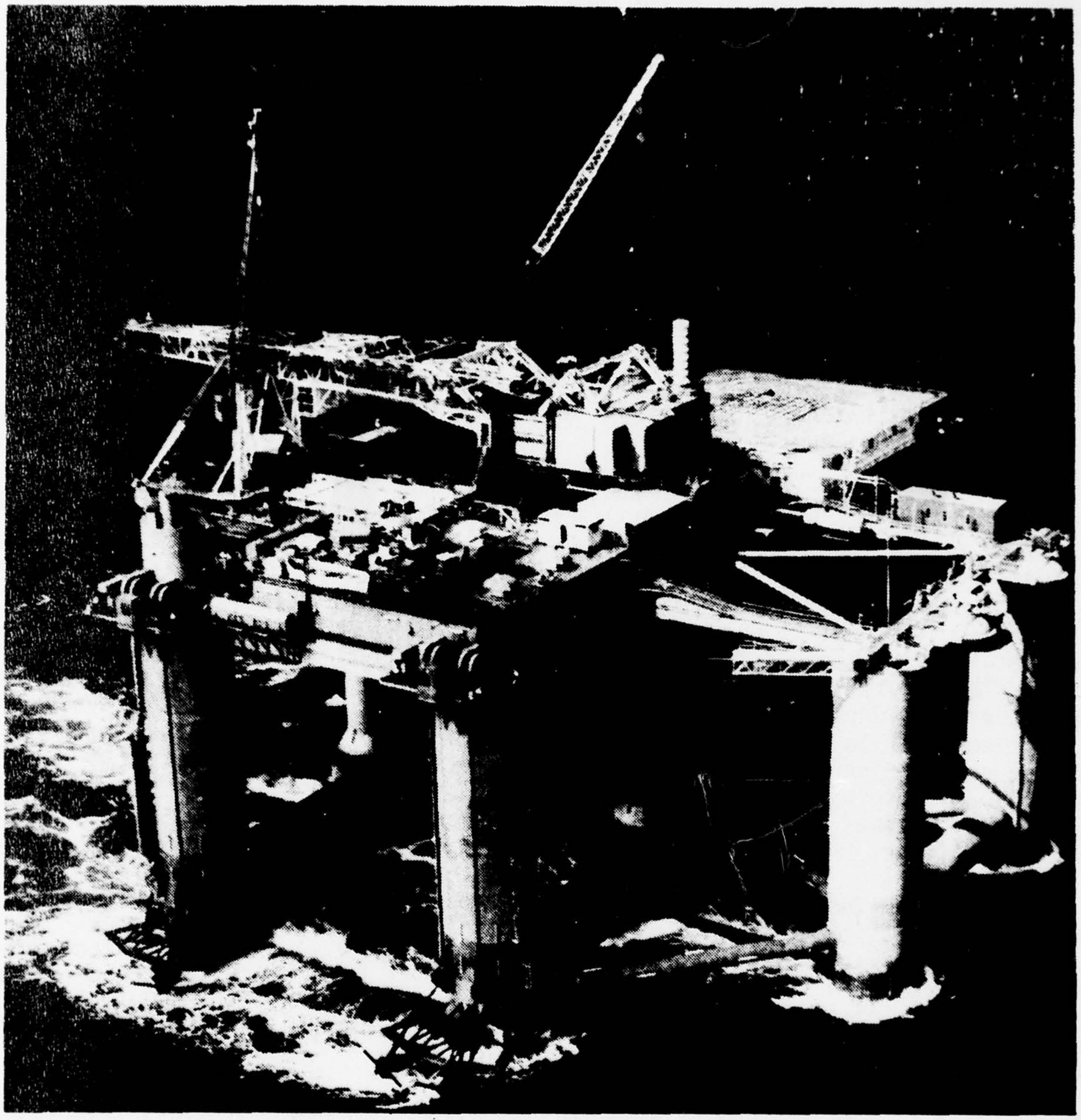

FIGURE S.5. ILLUSTRATION OF A SEMISUBMERSIBLE MODU
(Courtesy of ODECO, Inc., New Orleans, Louisiana)

Drill Ships and Floating Drill Barges

Drill ships are self-propelled MODUs with ship, catamaran, or trimaran hull form. The derrick is located at or near the center, with an opening below (the "moon pool") through which the marine riser (a flexible conductor pipe) and the string of drill pipe pass. Deck space is modified to accommodate the drilling equipment. Figure S.6 is an external view.

The initial drill ships were conventional ships converted for drilling service. The first new construction was in 1962 (Global Marine Inc.'s GLOMAR II). Since then a number of large new ships have been built, with four more planned or under construction now.

Because drill ships are highly responsive to wave action, innovations have been required to prevent excessive down time on location. Length and beam have been increased to reduce heave, and stabilization tanks provided to reduce roll. Mooring innovations are also designed to reduce the various motions. A 10-line mooring system may be used instead of the more usual 8-line system. The 10-line system allows the ship to be turned up to about 30 deg. to either side of its longitudinal axis. Thus a better orientation to the waves can be maintained, reducing motion.

Dynamic positioning is another innovation that increases drill ship capability. Dynamic positioning is the concept of mooring by means of propulsion equipment rather than fixed mooring lines. The ship's propulsive units are activated automatically, in response to sensor feedback, to maintain lateral position and heading. Thus there is no need to anchor on location. Dynamic positioning is practical only through the use of computers to continuously and immediately handle feedback on position and activate and control the propulsive units. The ability to hold the ship within acceptable limits depends upon ship size, the water depth, sea conditions, and the flexibility (in directing power from prime mover to thrusters) and response time of the propulsion equipment. Dynamic positioning permits drilling in water depths beyond the limits for conventional mooring systems. In addition, the dynamic system offers the advantages of minimal mooring time and free response to changing weather and water conditions.

The principal disadvantage is increased fuel consumption. Because of these tradeoffs, it may be said in general that dynamic positioning is most suitable when time on location is relatively short and moves relatively frequent or, as previously mentioned, for drilling in water depths that exceed conventional mooring capabilities. According to the "1976-77 Directory of Marine Drilling Rigs" (Ocean Industry, September 1976), 10-15 percent of drill ships worldwide are equipped with dynamic positioning systems.

Turret mooring, developed by the Offshore Company, provides advantages of both conventional mooring and dynamic positioning. In turret mooring, the mooring lines are connected to a turning table fitted around the moonpool, permitting the ship to turn 360 degree to maintain heading into the waves continuously. Ship's propulsive units are operated to maintain heading but do not have to be operated continuously since position is maintained by the anchors. Thus fuel consumption is lower than with dynamic positioning.

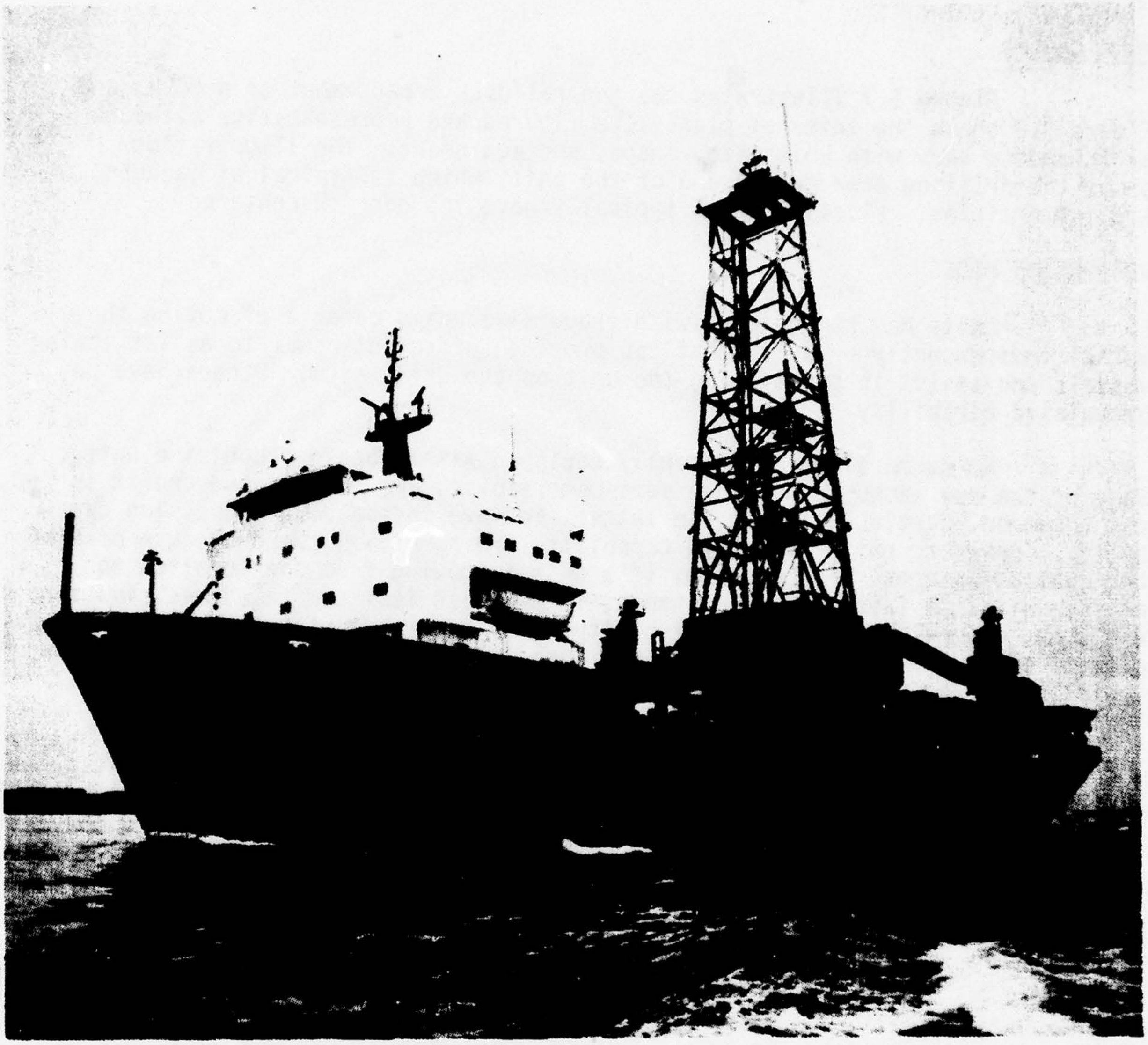

FIGURE S.6. ILLUSTRATION OF A DRILL SHIP
(Courtesy of ODECO, Inc., New Orleans, Louisiana)

Drill barges are like drill ships, but without propulsion capability, and usually smaller. Some of the older barges have the drilling rig cantilevered over the bow rather than centered. Floating barges generally are limited to shallower water than the other floating types because of vessel motion. The maximum water depth capability reported for any existing barge is 2,000 feet, and 600 feet is the most typical maximum water depth capability.

MODU Layout

Figure S.7 illustrates the general deck arrangement of a MODU, and Figure S.8 shows the internal plan. The figures are representative although arrangements vary with unit size, shape, and equipment. The illustration shows the drilling area to one end of the unit, which is typical of jackups and submersibles. Floating units typically have the derrick centered.

PROPULSION MODES

Units may be equipped with propulsive units capable of moving the vessel independently or units that can provide sufficient power to assist towing vessels and assist in positioning the unit on the drill site. Others have no propulsive capability.

No submersible is presently equipped with onboard propulsive units. Some of the new jackups, and more semisubmersibles, are so equipped and it is not uncommon, particularly for the latter, to have independent propulsion capability. However, units with this capability are sometimes towed because of time and cost advantages. For example, if a unit is moving from one location to another within a fairly short distance, it may cost less and take less time to use tugs, depending on their availability, than to bring out the required complement of marine personnel. Also, self-propelled semisubmersibles and jackups typically can be moved faster under tow than in the independent mode, so that towing may be desirable even for longer moves.

Propulsion-equipped units typically (and all self-propelled units) have all of the electronic navigation equipment and navigational aids found on a conventional ship, including radio direction finder, LORAN C, radar, and in some instances collision-avoidance radar systems, depth sounders, voice radio, etc. All are directly controlled from the bridge.

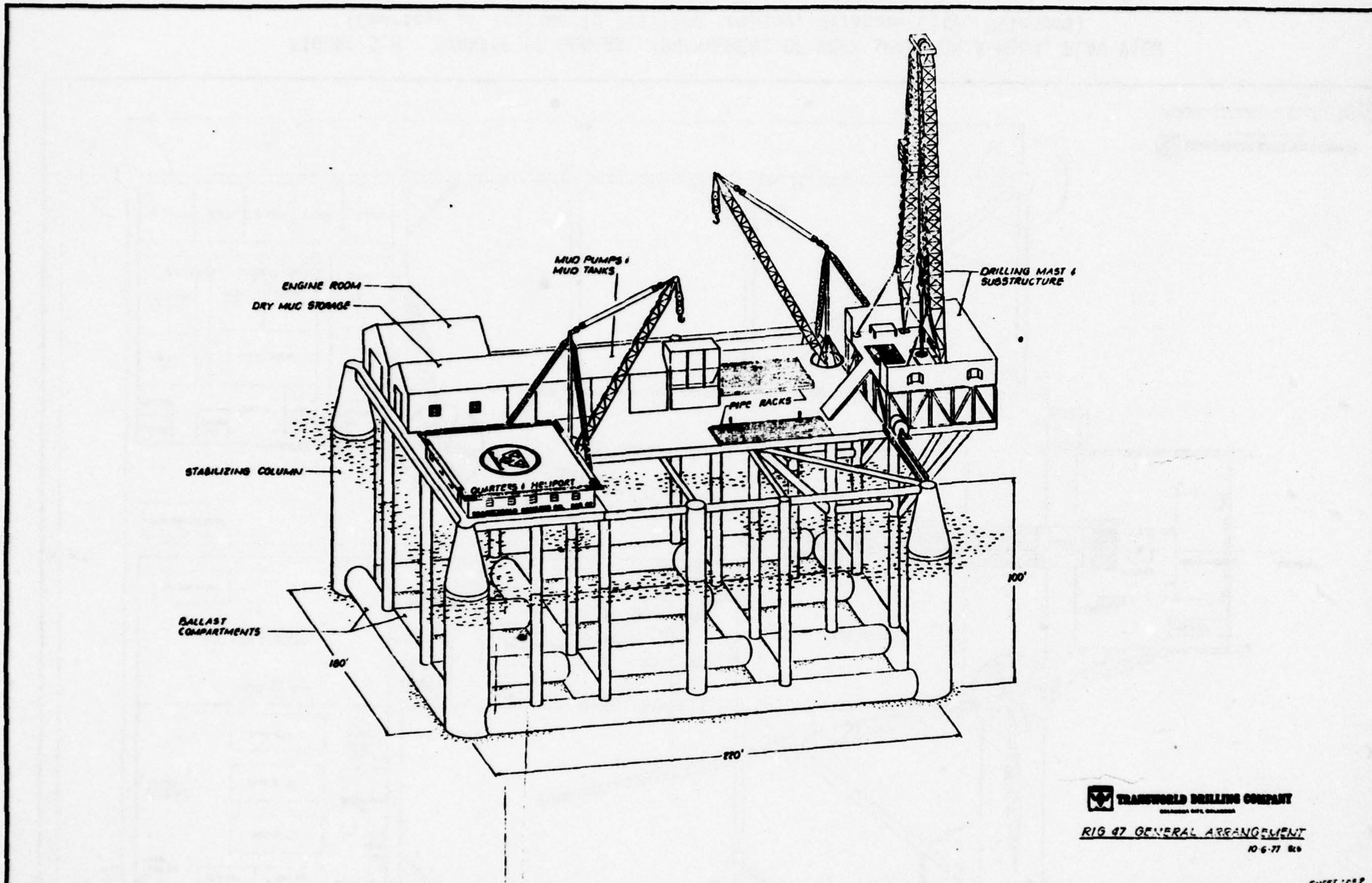

FIGURE S.7. EXAMPLE OF MODU PLATFORM ARRANGEMENT
(Courtesy of Transworld Drilling Company, Oklahoma City, Oklahoma)

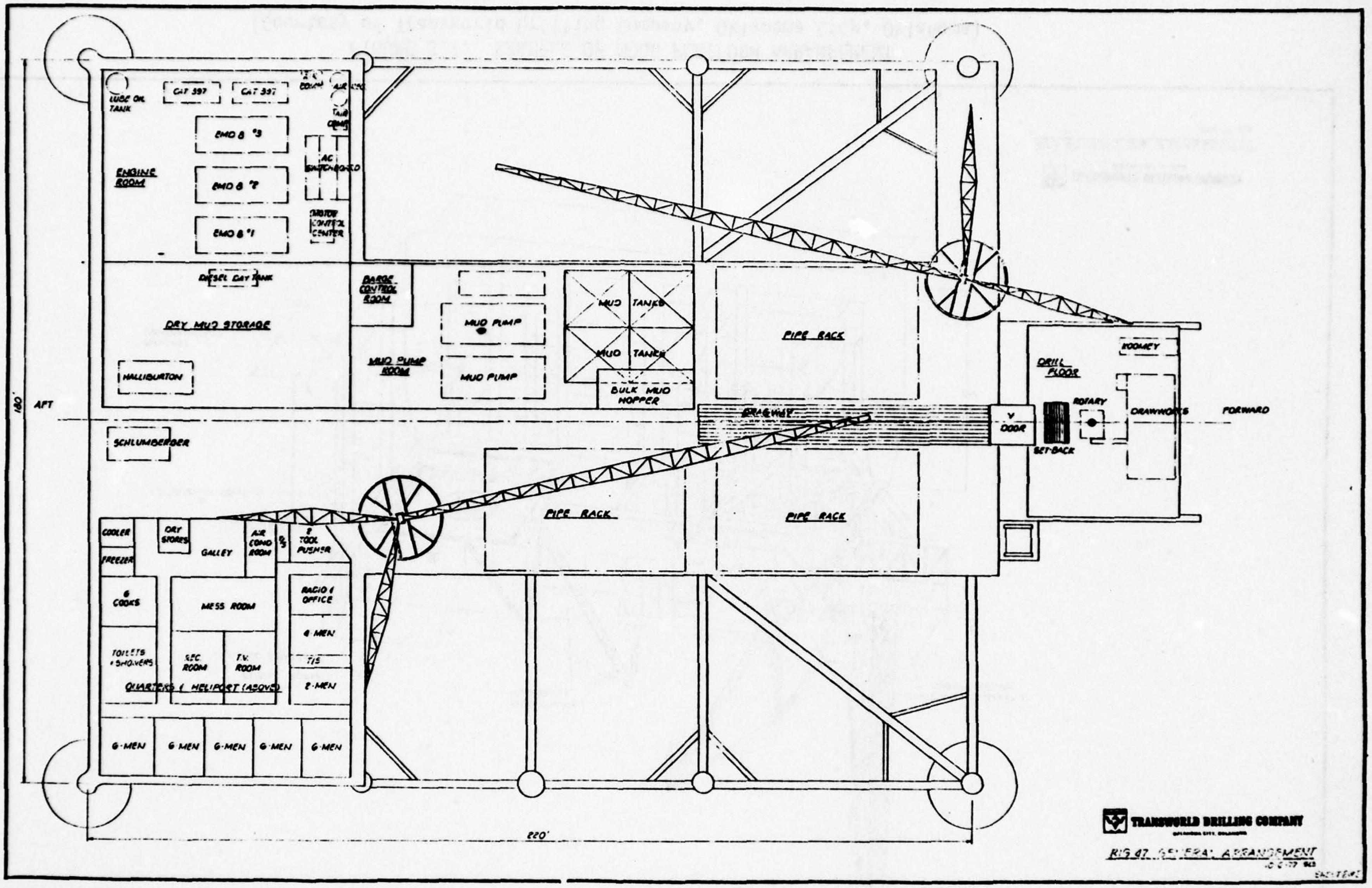

FIGURE S.8. EXAMPLE OF GENERAL ARRANGEMENT OF WORK SPACE ON A MODU, PLAN VIEW
(Courtesy of Transworld Drilling Company, Oklahoma City, Oklahoma)

MACHINERY PLANT

The prime movers (generally two or more diesel engines) supply mechanical and electrical power through a transmission system to the various equipment of the MODU, including propulsion units, if provided, and the drilling rig components. The plant consists of

- Prime movers and auxiliary systems (e.g., lubricating oil system, fuel injection system, cooling system, air induction system, starters, governors)
- Generators, generator controls
- Electrical distribution system and controls
- Electrical rectification or conversion equipment.

The specific equipment and arrangement of the machinery plant on a MODU are subject to the preferences of builder and owner. Differences are not patterned by MODU type. Neither does propulsion mode make any significant difference in the plant operations and maintenance.

MOORING AND POSITION-KEEPING ON LOCATION

MODUs that remain afloat for drilling, unless dynamically-positioned, use spread mooring to maintain position over the borehole. Spread mooring systems are designed to produce restoring forces when the unit moves laterally or vertically. The anchor loads are distributed over about half of the mooring lines while opposing lines may be slackened to reduce tension on the loaded lines. Eight or 10 lines are most commonly used. Line patterns are illustrated in Figure S.9. The lines may be of wire rope, chain, or a combination, depending on the water depth. The anchors are deployed and retrieved by specially-fitted anchor handling boats.

Lateral position over the borehole is maintained by adjusting anchor scope and tension. Propulsive units, if available on the MODU, are operated to reposition the unit as required. On turret-moored ships (anchor lines attached to a roller-mounted turning table in the ship's well, beneath the derrick), the thrusters can be activated to change heading without moving the anchors or getting off position over the borehole.

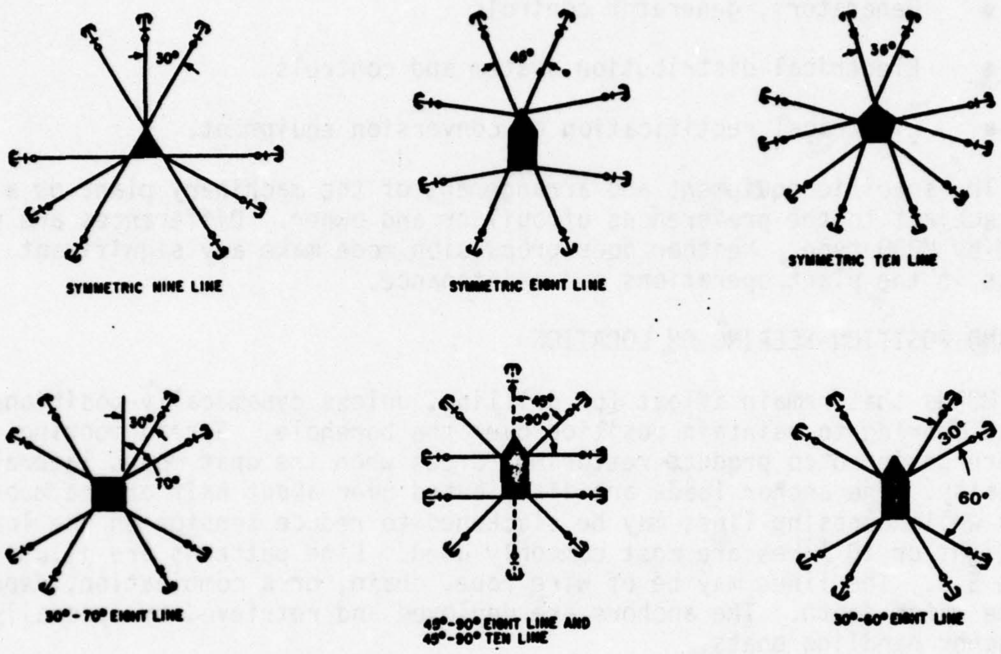

FIGURE S.9. TYPICAL SPREAD MOORING PATTERNS
(Source: The University of Texas at Austin, Petroleum Extension Service, Rotary Drilling (a Home Study Course), Unit 5, Lesson 2: "Spread Mooring Systems." Reprinted with permission.)

Horizontal displacement is monitored on floating units by sensing equipment. Measuring the deflection of the marine riser which houses the drill string is one common method used to detect horizontal displacement. Various types of riser position-indicating devices are used. Dynamically-positioned MODUs use more elaborate automatic sensing equipment including taut-wire inclinometers and acoustic systems in addition to the riser angle method.

Mooring line tension is monitored to avoid overstress. Chain line tension may be measured in various ways, including, for example by mounting the windlass and chain stopper assembly on a load cell. Wire rope tensions are typically measured by deflection angle from a straight line. The data are read from gauges or electronic indicators or recording devices.

Jackup drilling units are anchored temporarily while the legs are set and lifted off. Submersible units are not anchored but rather are held in position by the towing vessels during ballasting/deballasting operations.

DRILLING SYSTEMS AND EQUIPMENT

Drilling systems and equipment are essentially the same on all MODUs, except that on floating units (semisubmersibles, drill ships, and drill barges) different equipment is used to conduct the drill string from the unit to the sea floor and underwater blowout prevention equipment must be used. Drill ships use automatic pipe-handling systems because of the potential for vessel motion to make pipe handling difficult in some waters. Other floating units may or may not have such systems.

The marine riser used on floating units is a flexible string of tubular sections connected by mechanical locking devices that conducts the drill string between the platform and the hole being drilled. The riser is designed to withstand lateral and vertical displacement of the MODU and the stress and loading forces which may be experienced due to wind and sea conditions. The forces and loads tending to bend the riser are offset by axial tension applied at the top of the riser and/or by buoyancy modules connected to the string. The riser also serves as a conduit for the return of drilling fluid pumped down the drill pipe and the formation cuttings flushed out by the drilling fluid. Bottom-standing units use rigid conductor pipe.

The installation of subsea blowout preventers (BOPs) is required on units that drill in the floating condition. The BOP on floating units is placed under the water between the wellhead and the bottom of the marine riser. In the event of a well flow, it is closed in order to protect the riser and all equipment (and personnel) above that point from the powerful force of the rising fluid. On bottom-standing units, the BOP assembly is located directly under the drill floor. On these units the wellhead is above water and because the unit is stationary while drilling, there is no need for a marine riser.

Figure S.10 illustrates the basic drilling systems and components which are found on all MODUs (and on land rotary drilling rigs). The figure insert shows the marine riser (which could be replaced by rigid conductor pipe on a jackup or submersible MODU) and the placement of the BOP on a floating unit.

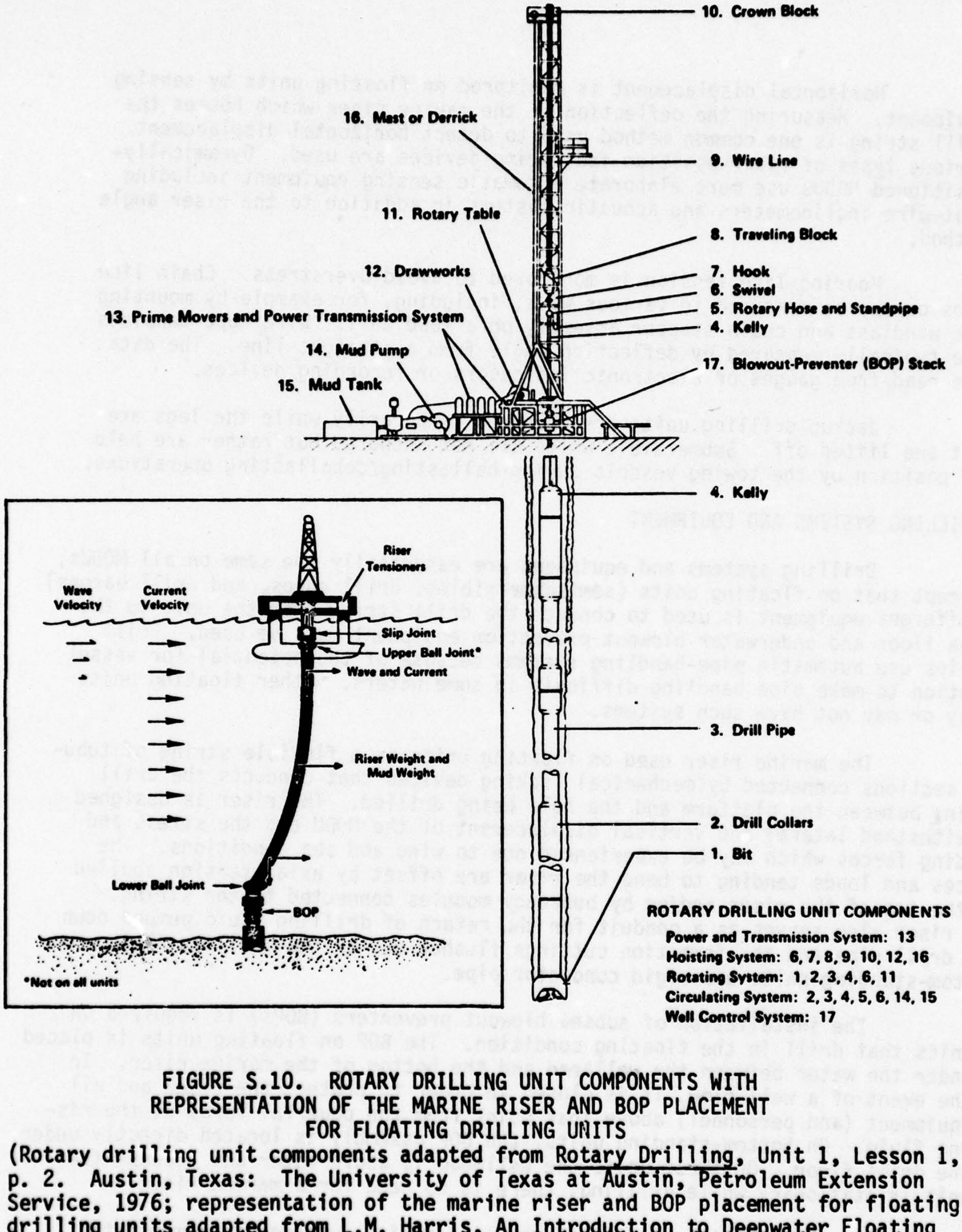

FIGURE S.10. ROTARY DRILLING UNIT COMPONENTS WITH REPRESENTATION OF THE MARINE RISER AND BOP PLACEMENT FOR FLOATING DRILLING UNITS

(Rotary drilling unit components adapted from Rotary Drilling, Unit 1, Lesson 1, p. 2. Austin, Texas: The University of Texas at Austin, Petroleum Extension Service, 1976; representation of the marine riser and BOP placement for floating drilling units adapted from L.M. Harris, An Introduction to Deepwater Floating Drilling Operations. Tulsa, Oklahoma: Petroleum Publishing Company, 1972.)

HAZARDS AND CASUALTY HISTORY IN MODU OPERATION

Mobile offshore drilling units face special hazards because of the marine environment, in addition to the usual hazards of exploratory drilling that must be dealt with regardless of where the drilling operations are conducted.

Industrial Hazards

The primary industrial hazard is formation pressure, which if not controlled may result in a blowout—the uncontrolled flow of well fluid. If a blowout threatens, proper action must be taken immediately to prevent a potentially catastrophic situation in which the MODU could be damaged or lost, personnel injured or killed, and the environment damaged.

On units that drill in the floating condition, the use of subsea blowout prevention equipment, and the wear induced in that equipment and in drill stem components by vessel motion, require especially rigorous monitoring and maintenance. Weakness in drill stem components or the BOP system would reduce the ability to control a kick.

Failure of certain machinery on any unit could, in some instances, aggravate a critical condition; for example, mud pump failure during well control procedures would be very serious (although MODUs are equipped with two mud pumps, and it is unlikely that both would be malfunctioning at once). Thus inspection and routine maintenance on the machinery plant, the drilling equipment driven off it, and the drilling fluid circulating system must be attended to carefully.

Other industrial hazards potentially affect individual personnel but not, in themselves, the integrity of the MODU. For example, heavy equipment is used on MODUs, much of which has moving parts such as belts, chains, and lines by which personnel can be injured. There are also usual hazards of using hand tools and power tools, moving heavy materials, and working with or near suspended loads. Personnel must also be alert to the possibility of falling objects from overhead since work is done above the drill floor (e.g., stringing lines, pipe handling) at the same time that work is progressing on the floor.

Hydrogen sulfide gas may also be a threat to personnel safety on some drilling jobs. Deep, high pressure reservoirs may contain hydrocarbons infused with this deadly poisonous gas, which can quickly cause the respiratory system and heart to stop functioning. In addition to its severe effects when inhaled, H_2S forms an explosive mixture with air between roughly 6 to 30 percent by volume. Stringent precautions are required for drilling when this gas may be present. Requirements for personnel training, operating procedures, equipment, and the mud program are specified by the U.S. Geological Survey.[2]

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[2] U.S. Department of the Interior, Geological Survey, Conservation Division, "Safety requirements for drilling in a hydrogen sulfide environment," Outer Continental Shelf Standard No. 1, first edition, February 1976.

Fire and explosion are also major threats in the event of a blowout. In addition, under normal operating conditions there are numerous sources of fire.

Marine Hazards

The following hazards intrinsic to MODU operations were designated as marine in this study:

- The requirements for water transit and the navigational peculiarities of MODUs
- Unique equipment, deck structures and heavy variable loads
- The mechanics and physics of platform elevation and lowering for jackup units
- The ballasting procedure for submersible and semisubmersible units
- The relative isolation of a MODU from outside assistance in an emergency
- The procedures and equipment used to get personnel off a MODU in an emergency
- Adverse weather and water conditions, which may complicate various aspects of MODU operations and may require suspension of operations and abandonment.

The marine hazards are briefly discussed below, with interactive effects brought out. Then a summary of casualty data is provided. The casualty history confirms that the marine hazards listed above are the most significant concerns in addition to the blowout threat.

Navigation. Any self-propelled MODU faces the usual hazards associated with control of large vessels, including variable meteorological conditions and waterway characteristics. Vessel traffic may also be a factor, although MODUs (except drill ships) do not operate independently in berthing areas or restricted channels.

Jackup and semisubmersible MODUs, some of which may transit self-propelled, have less maneuverability than ships because of their hydrodynamic characterisitcs. When under tow, both of these types of MODU are more affected by winds than are conventional ships, because of greater projected sail area above the water line.

Further, a greater portion of the sail area is located higher above the water line. This is especially pertinent to jackups under tow with their legs elevated. The upper 100 feet of a jackup's legs could get as much wind force as the lower 200-300 feet, which means that the moment exerted by the force over the upper 100 feet could be as much as twice as great as the moment exerted over the lower portion. The righting moment must be capable of exceeding these higher heeling or upsetting moments.

When a MODU is towed, the sources of danger include the towing arrangement and lines, particularly in relation to the wind/wave stresses that are experienced, the coordination of tug actions, and coordination of any actions that may be taken aboard the MODU itself. The last includes operation of onboard propulsive units, adjustments of jackup leg heights, and changes in semisubmersible and submersible draft by ballasting/deballasting. Other conditions such as waterway characteristics and vessel traffic may pose threats just as they do to any vessel under tow.

According to the information obtained in this study, the towing vessels typically take responsibility for navigation when a MODU is towed. The exception is the case of drill ships; the MODU master may direct the tow, as is done when conventional ships are assisted by tugboats. The task analysis was written to include navigation under tow as a MODU responsibility, so as not to omit those essential duties. However, since in practice a tugboat captain may take responsibility, there is a significant gap in the marine requirements for MODU safety left by this study. This is discussed later in the conclusions and recommendations section.

Unique Equipment, Deck Structures and Variable Loading. Deck equipment creates another special hazard in the underway operations of MODUs, whether towed or self-propelled. On some units, the derrick can move fore, aft, and athwartships. Cranes are movable as well. This equipment, along with drill pipe and other drilling materials are secured on deck. If this equipment should break loose and shift to one side, it could cause the unit to capsize.

The drilling rig, machinery and equipment, and the deck structures are permanent, fixed weight. In addition, consumable items such as drill pipe and collars, cement, dry mud, blowout preventers, fuel oil, potable water and ballast are carried on MODUs. These items which comprise the variable load may make up a large part of the total weight. Their weight must be known at all times since the MODU hull is designed to carry certain loads. Maximum draft calculated for the unit should not be exceeded for moving or while drilling in a floating condition.

Weight placement also can affect stability. Structural alterations may require that the center of gravity, center of buoyancy, and righting arms be recalculated. Weight changes by the movement and use of consumables affect the natural period of roll underway and may result in undesirable heel and trim on location, which may need to be compensated for by ballast changes.

Jacking Operation. The jacking operation may be the most critical stage in relocating a self-elevating drilling unit. At the drilling site, the unit's legs, which were raised for transit to the site, are lowered by means of the jacking motors until the footings reach the mudline. A typical three-legged unit would have 48 electric jacking motors, 16 controlling each leg. It is necessary to assure that the legs are lowered (and raised) uniformly and do not bind within the fixed guides on the platform itself. If the legs should bind, the jacking gear, legs, or both could be damaged.

When the footings have reached the mudline, they are slowly forced down into the soil of the sea floor to a level where the soil resistance, or bearing capacity, exceeds the footing load being applied. This procedure is called pre-loading. The objective is to make sure the legs are set on stable soil, so that the unit will not tip when the platform is raised to operating height above the water.

Then the platform is raised by operation of the jacking motors. The platform climbs the portion of the legs remaining above the water to a prescribed height sufficient to protect it from wave forces. The prescribed distance between the hull bottom and the water surface is called the air gap. Air gap + water depth + footing penetration may not exceed the leg length that can safely extend below the hull.

Detailed surveys of bottom conditions are made prior to moves to determine the leg penetration and other factors. The optimum form of the lower end of the leg differs for soft soils and hard, sandy bottoms. In soft soils the legs tend to sink, and with sandy soils bottom currents may scour the sand around the legs. Design variations are used to minimize the negative effects of such conditions, but, nevertheless, an experienced jacking operator is required.

In returning the platform to floating condition, the buoyancy of the hull is utilized to free the legs from the bottom. One leg may cause difficulty because of its penetration depth or because of mud suction. When this occurs, there is particular danger of the unit tipping.

Sea conditions govern whether positioning and jacking operations may be conducted. When sea conditions are severe, the unit cannot be safely positioned with sufficient accuracy. If jacking operations were attempted in high sea conditions, wave forces would be placed on the platform when it was at a height below the minimum air gap. This could cause the platform to "jackhammer" (drop back down the legs), damaging the jacking machinery or the legs themselves. In the extreme, the unit could capsize.

Ballasting. Some submersible units are set on bottom one end at a time while others are lowered in a level condition, as are semisubmersibles. When one end is lowered first, the height of the metacenter of the MODU is reduced as that end submerges, and free surface in the ballast tanks further decreases stability. However, the columns and the part of the hull on the surface provide sufficient stability, and when the submerged end engages the bottom, resistive force creates a positive righting moment. When a unit is lowered level, it is least stable just after the lower hull goes beneath the surface; this condition is corrected as ballast water is added to further lower the unit.

When a submersible unit is raised to leave a location there are again transient conditions requiring caution. The unit is most vulnerable when one end has surfaced and the other has just left the sea floor; only part of the lower hull stability has been realized and the righting moment created by the resisting force of the sea floor has been lost. There may be difficulties caused by suction of the sea floor. Soil adhering to the hull can cause a seal that does not allow water to get underneath. This can prevent the hull from rising when ballast is pumped out. Under these conditions it is important not to force the hull free by deballasting too quickly as that could cause the hull to rise too quickly with severe heel or trim.

Relative Isolation. It is evident that any unit operating at sea, be it a fixed structure, a conventional vessel, or a MODU, is relatively isolated, although personnel from ashore may be brought out by helicopter and various types of support vessels go out to MODUs on location. This is a simple thought, but important in relation to emergencies or potential emergencies such as an impending storm, fire, structural damage, etc. MODU personnel will probably have to respond to emergencies unassisted, at least for a while. Moreover, the avenues of escape are limited, and abandonment has hazards of its own. Thus MODU personnel have to be thoroughly trained in what to do to protect the MODU if possible and to protect themselves.

Personnel Transfer Procedures and Equipment. Personnel travel to MODUs by helicopter or support vessel. Transfers onto the MODU from a vessel alongside are made by means of personnel baskets, ropes and ladders. All forms of transfer require caution and the observance of safety rules.

Abandonment in an emergency can be particularly hazardous. On land, personnel can normally get away from the site quickly, without assistance. Offshore personnel may be evacuated by helicopters or support vessels, if time and other conditions permit. If not, it is necessary to use lifesaving appliances (LSAs) as provided on the particular unit. LSAs include inflatable, enclosed liferafts; enclosed lifeboats; and survival capsules (spherical enclosed lifeboats).

LSAs are most likely to be used under conditions of confusion or panic, in heavy seas, with the MODU damaged in some way and personnel possibly injured and/or seasick. There may be no access to one or more of the available devices and in rough water it can be extremely difficult to get a lifeboat away from the MODU.

It should be noted that ultimately MODU personnel must assure their own safety. They must be able to launch the devices available to them and get away from the MODU. Nevertheless, they have to be assisted by rescue craft. Coordination is important, and the rescuing personnel must also be well trained. Here again, as in the towing situation, a larger system is involved.

Adverse Weather and Water Conditions. It is evident that bad weather with accompanying heavy seas can intensify all of the hazards of MODU operations. Casualty data show that 26 percent of all cases in which MODUs have been severely damaged are attributed to storms. When one considers the total amount of operating time in relation to the portion of that time during which storms are experienced, their contribution to casualties would have to be proportionately very large.

Casualty History

Casualty analysis is outside the scope of this study. However, available data were reviewed as a way of evaluating the significance of operational hazards. The primary source of data for this summary is an analysis done by John R. Huff, of Western Oceanic in Houston. Mr. Huff's results were published in the Oil & Gas Journal, November 1976. His is the most thorough analysis on a single, comprehensive data base that we have found published.

The Huff analysis covers casualties that occurred worldwide from January 1955 through June 1976. All cases reported on involved estimated damage to the MODU of at least $500,000.

Estimates of casualty incidence assume that all extant MODUs were operating full time during the period covered. That is, idle time is disregarded. This deflates the incidence estimates to some extent. We were not able, within the scope of this effort, to refine the measure of exposure to take into account idle time, much less introduce other refinements such as the frequency and duration of moves and adverse weather/water conditions.

Finally, it is noted that available data summaries discuss casualties by type of MODU without reference to baseline numbers of operating units of each type. Such data could be obtained, but we were not able to do so for a period of years back within the scope of this study. It is therefore difficult to make meaningful comparisons of the casualty experience of the different types of MODU.

Marine versus Industrial Casualties

Three kinds of marine casualty and two kinds of industrial casualty are represented by the Huff data:

Marine

- —Casualties to MODUs under tow.
- —Casualties while moving on/off location. (We included jacking operations here - one case.)
- —Casualties resulting from storms.

Industrial

- —Blowout.
- —Casualty occurring under "normal conditions." (This category includes casualties on location resulting from such things as leg failure and fire/explosion, when neither a blowout nor a storm was involved.)

Of the 98 casualties occurring from January 1955 through June 1976 that were included in the Huff analysis, approximately two-thirds were characterized as marine rather than industrial in origin. A breakout of the cause categories is given in Table S.3. The table also compares the number of cases in which the MODU was salvaged or not salvaged, which gives some indication of the severity of the event beyond the minimum estimated damage criterion of $500,000. The ratios of salvaged/not salvaged cases are identical for marine and industrial casualties. "Storm" is the one category in which equally as many MODUs were lost as were salvaged; however, in view of the small numbers, this difference cannot be interpreted with confidence.

TABLE S.3

MARINE AND INDUSTRIAL MODU CASUALTIES WORLDWIDE
(January 1955-June 1976)

Casualty Description	Salvaged	Not Salvaged	Total
Under tow	19	8	27
Moving on/off	8	5	13
Storm	13	13	26
Marine Subtotal	40	26	66
Normal Conditions	8	3	11
Blowout	12	9	21
Industrial Subtotal	20	12	32
OVERALL TOTAL	60	38	98

Table S.4 provides a comparison of the casualty history of different types of MODU. It is shown that jackups have been involved in many more casualties than the other types of units. This may be at least partially an indication of greater vulnerability of jackups. However, there are many more jackups than MODUs of any other type, as was shown in Table S.1, for the current year. This has been the case for at least the past 10 years, and even previous to that time, though by a smaller margin. Also, the jackup is known as the workhorse of the industry, and units of other types, especially the newer floating units with higher operating costs, may have an unproportional amount of idle time. These things are said as a caution against concluding that jackups are necessarily more casualty prone than other MODUs. The data presented here cannot support such a conclusion.

TABLE S.4

WORLDWIDE CASUALTY HISTORY FOR DIFFERENT TYPES OF MODU
(January 1955-June 1976)

MODU Type	Casualty Description					Total
	Under Tow	Moving On/Off	Storm	Normal Conditions	Blowout	
Jackup	23	12	10	5	11	61
Submersible	1	1	3	-	2	7
Semisubmersible	2	-	8	3	3	16
Drill Ship	-	-	2	2	2	6
Floating Drill Barge	1	-	3	1	3	8
TOTAL	27	13	26	11	21	98

OVERVIEW OF TASK ANALYSIS RESULTS

The Functional Job Analysis data sheets (task analysis sheets) are presented in Volumes II and III of the report. They contain detailed specifications of the tasks and associated training needed to enable personnel to meet given standards for task performance. There is a sheet for each task, and the analysis was performed for each type of MODU. In all, some 500 tasks were specified. A substantial number are applicable to more than one type of MODU. Industrial tasks are the same regardless of MODU type, except there are additional tasks for the MODUs that drill in the floating condition—namely the tasks of installing the marine riser and subsea blowout preventers. (Position maintenance of floating units on station was treated as a marine function.)

Tables S.5 and S.6 indicate in general where MODU design type affects the tasks. The tables cover navigation and positioning (the latter includes moving on/off and maintaining position during drilling from a floating MODU). All other functional requirements (power plant operations, loading/offloading,

TABLE S.5

OVERVIEW OF NAVIGATIONAL REQUIREMENTS BY MODU DESIGN TYPE

Requirements (Corresponding to Objectives under FJA Goal I for all MODU types)	MODU Design Type				
	Jackup	Submersible	Semisubmersible	Drill Ship	Floating Drill Barge
Identify and respond to potentially hazardous conditions in order to avoid collisions, rammings, and groundings while maneuvering in <u>self-propelled</u> mode	●	(No submersible currently has propulsive units.)	●	●	
Monitor MODU motions in seaway when underway in <u>self-propelled</u> mode and make necessary adjustments in order to avoid excessive motions, weight shifts, and capsizing	●	(No submersible currently has propulsive units.)	●	●	
Monitor <u>towed MODU</u> motions in seaway due to towlines in order to detect excessive MODU motions that may cause weight shifts and/or capsizing	●	●	●	(Applicable to drill ships when towed.)	●
Furnish propulsion assistance with onboard units while being towed	●	(No submersible currently has propulsive units.)	●	(Applicable to drill ships when towed.)	

TABLE S.6

OVERVIEW OF POSITIONING REQUIREMENTS (MOVING ON/OFF) AND POSITION MAINTENANCE, BY MODU DESIGN TYPE

Requirements (Corresponding to Objectives under FJA Goal II for all MODU Types)	MODU Design Type				
	Jackup	Submersible	Semisubmersible	Drill Ship	Floating Drill Barge
Position MODU over hole site using only propulsive units, only towing vessel(s), or combination thereof	•	• (positions with towing vessels only)	•	•	• (positions with towing vessels only)
Anchor MODU in position	•		•	•	•
Jack up MODU to drilling position/jack down to required underway draft	•				
Ballast MODU to bottom-sitting mode/ deballast to underway draft		•			
Ballast/deballast MODU to drilling draft/ underway draft			•	•	•
Haul in and retrieve anchors	•		•	•	•
Requirements (Corresponding to Objectives under FJA Goal III, MODUs that remain afloat for drilling)					
Ascertain lateral position			•	•	•
Reposition MODU using anchors and (if applicable) onboard propulsive units			•	•	•
Ascertain ballast/trim condition			•	•	•
Reballast/retrim as necessary by calculating requirements and operating saltwater ballast system)			•	•	•

drilling operations, emergency response, and personnel supervision and training), with the one exception noted above, do not differ significantly on the basis of MODU type. Nor do they differ consistently on the basis of any other classifying variable according to the observations and literature analysis performed in this study.

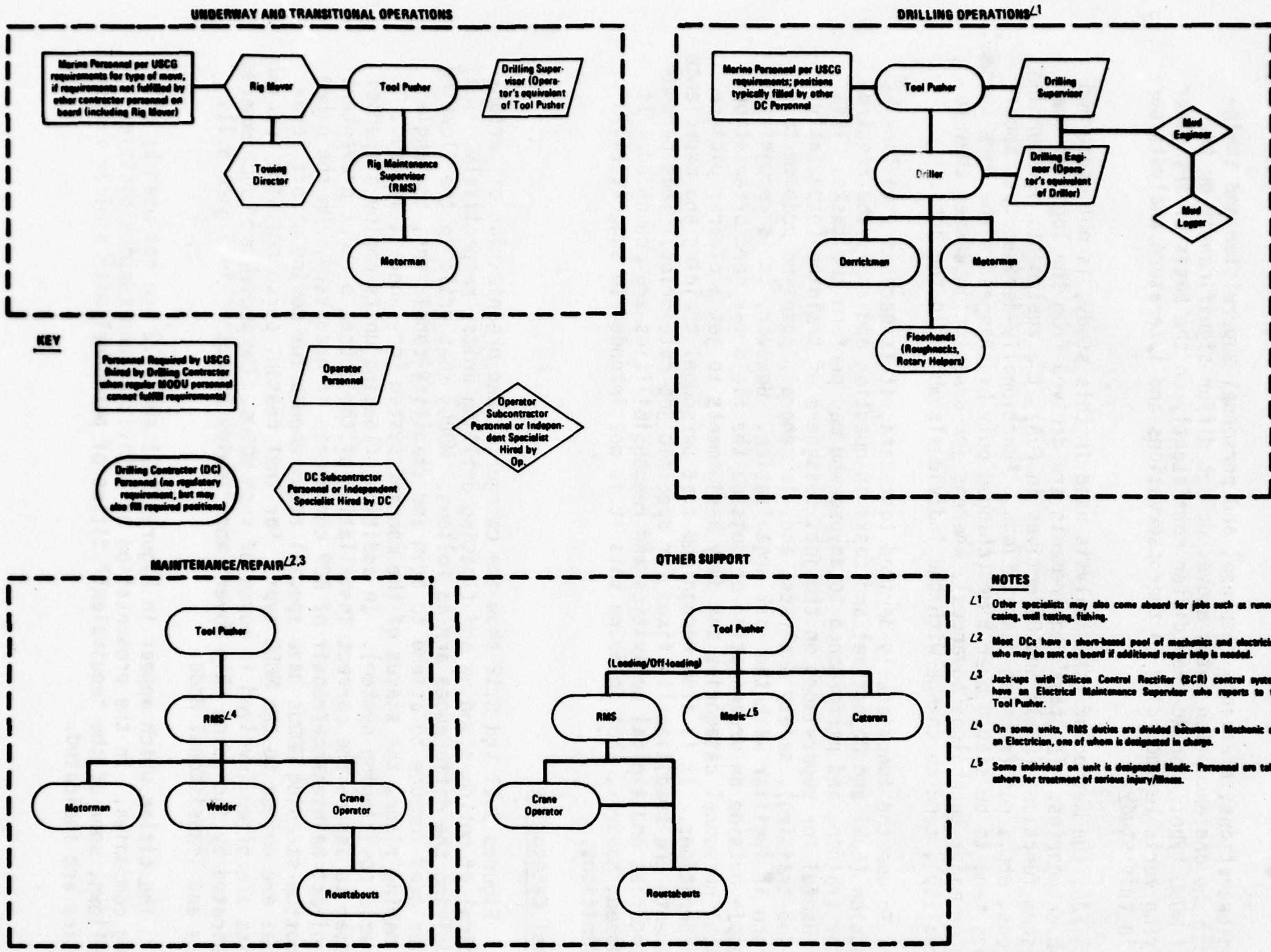
FJA, the method of task analysis used in this study, is not concerned with job categories. The task requirements are derived from the logic of the work system functions (Goals and Objectives in FJA), the equipment, surrounding conditions, etc., not from job descriptions. Functionally-derived task specifications tend to be stable over time (changed only by changes in the work system mission or major technology advances), whereas job descriptions (when they reflect reality), tend to change with the individuals who hold the jobs.

To use the functionally-derived task data, it is necessary to look at the function (Goal and Objective) and tasks in question and apply the requirements for training and performance to anyone who may perform the tasks. This is very useful for supervisors on the job, designers of training (especially on-the-job training), safety analysts, and, in general, poses no problem to anyone who is familiar with the work organization. However, it is recognized that people outside an organization or outside the field may need orientation to typical personnel categories and duty assignments to get a clearer picture of the operations. It is also recognized that personnel training and experience requirements are traditionally fixed for specific job categories. Thus personnel categories and typical activities and responsibilities are presented. It is stressed, however, that in doing this it is not intended to suggest rigid job definitions.

Personnel Categories

Figures S.11 and S.12 show the categories and organization of personnel typical of bottom-standing and floating drilling units, respectively. The needs driving the differences are as follows. MODUs that drill in the floating condition need someone to attend to trim and stability conditions, the angle of the marine riser, the status of the mooring system (or, when it is used, the dynamic positioning system). In addition, floating units employ a special technician to assure the correct installation of the subsea blowout preventers and to direct maintenance/repair of BOP components if necessary. On the other hand, bottom-standing MODUs have special requirements for moving on/off location that are unique to the MODU type. For that reason, personnel with special expertise are often involved in moves of such MODUs. The presence of such experts was indicated by including "Rig Mover" and "Towing Director" in Figure S.11, Underway and Transitional Mode.

The titles which appear in Figures S.11 and S.12 are not used by all drilling companies. In the presentation of activities and responsibilities that follows, some of the "equivalent" titles of personnel with similar responsibilities are indicated.



NOTES

∠1 Other specialists may also come aboard for jobs such as running casing, well testing, fishing.

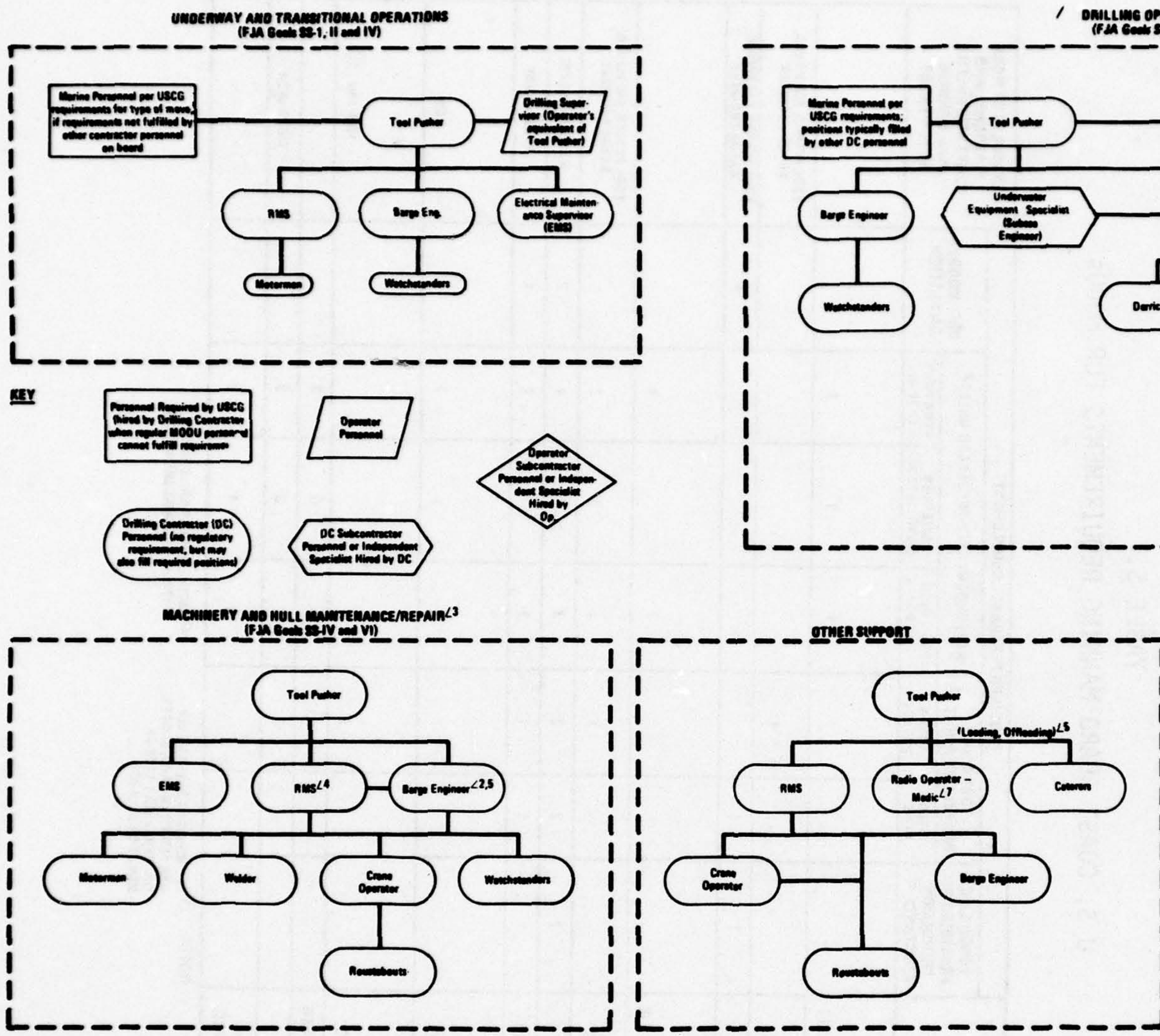
∠2 Most DCs have a shore-based pool of mechanics and electricians who may be sent on board if additional repair help is needed.

∠3 Jack-ups with Silicon Control Rectifier (SCR) control systems have an Electrical Maintenance Supervisor who reports to the Tool Pusher.

∠4 On some units, RMS duties are divided between a Mechanic and an Electrician, one of whom is designated in charge.

∠5 Some individual on unit is designated Medic. Personnel are taken ashore for treatment of serious injury/illness.

FIGURE S.11. PERSONNEL CATEGORIES AND ORGANIZATION TYPICAL ON BOTTOM-STANDING MODUs



NOTES

∠1 Other specialists may also come aboard for jobs such as running casing, well testing, fishing.

∠2 On drill ships, Barge Engineer functions are performed by the Master and Assistants.

∠3 Most DC's have a shore-based pool of mechanics and electricians who may be sent on board if additional repair help is needed.

∠4 On some units, RMS duties are divided between a mechanic and an electrician, one of whom is designed in charge.

∠5 The Barge Engineer has general responsibility for hull maintenance.

∠6 The RMS is responsible for loading and off-loading, but the Barge Engineer (or Master) is consulted to assure maintenance of stability.

∠7 Some individual serves as Radio Operator (when no FCC-licensed operator is on board); usually also serves as Medic. Personnel are taken ashore for treatment or serious injury/illness.

FIGURE S.12. PERSONNEL CATEGORIES AND ORGANIZATION TYPICAL ON MODUs THAT DRILL IN THE FLOATING CONDITION

As stated previously, this study was directed to the work of drilling contractor personnel only. Specialists furnished by the lease operator were included in the organization charts to complete the picture of the people involved.

The organization charts refer to marine manning requirements set by the U.S. Coast Guard. They vary, as shown in Table S.7, depending on the operating mode and propulsion capability of the MODU and the duration of the move. Regular drilling contractor personnel often fulfill some or all of those requirements as indicated in the table.

TABLE S.7

U.S. COAST GUARD MANNING REQUIREMENTS FOR MODUs

MARINE PERSONNEL CATEGORY	REQUIRED PERSONNEL COMPLEMENT: TOWED UNIT PROVIDING NO PROPULSION ASSISTANCE [1]	TOWED UNIT, PROPULSION ASSIST [2]		INDEPENDENT SELF-PROPELLED UNIT [2]			UNIT MOORED ON STATION	EXAMPLES OF MODU PERSONNEL WHO SOMETIMES FULFILL USCG MANNING REQUIREMENT
		FIELD MOVE	OCEAN VOYAGE	FIELD MOVE (< 16 hr)	INTERMED. MOVE (16-72 hr)	LONG MOVE (> 72 hr)		
MASTER								
UNLIMITED CONVENTIONAL LIC				1	1	1		
SPECIAL INDUSTRIAL LIC			1					TOOL PUSHER, RIG MOVER, BARGE ENGINEER
UNLICENSED	1	1					1	TOOL PUSHER, RIG MOVER, BARGE ENGINEER
MATE								
UNLIMITED CONVENTIONAL LIC						1		
SPECIAL INDUSTRIAL LIC			1	1	2	2		TOOL PUSHER, RIG MOVER, BARGE ENGINEER
ABLE SEAMAN	2	2	2	3	3	4	2	WATCHSTANDERS
ORDINARY SEAMAN	1	1	1	1	1	2	1	ROUSTABOUT
CHIEF ENGINEER								
SPECIAL INDUSTRIAL LIC				1	1	1		RMS
ENGINEER								
SPECIAL INDUSTRIAL LIC			2					RMS, EMS
ASSISTANT ENGINEER				1	2	3		
OILER			2	2	3	3		MOTORMEN
RADIO OFFICER (IF REQUIRED BY FCC)				1	1	1		

NOTES [1] ALL MOVES OF SUBMERSIBLE AND FLOATING DRILL BARGES. MOST FREQUENT TYPE OF MOVE FOR JACK-UPS

[2] MOST MOVES OF DRILL SHIPS. TYPICAL OF SEMISUBMERSIBLES.

Typical Marine and Industrial Activities and Responsibilities of MODU Personnel

Activities and responsibilities are categorized as primarily marine or primarily industrial, where such a distinction seemed appropriate, since the study addressed marine-related training and experience needs. In terms of the task analysis structure (FJA Goals) the distinctions were made as follows:

Primarily Marine Functions

- Navigation to or from the drilling site
- Positioning on the drilling site (i.e., moving on/moving off location; "Transitional Mode" in Figures S.11 and S.12)
- Position-keeping at the drilling site
- Transfer operations between the MODU and offshore supply vessels.

Primarily Industrial Functions

- Drilling operations
- Maintenance of drilling systems and equipment.

Applicable to Both the Marine and Industrial Aspects of MODU Operations

- Operation and monitoring of the machinery plant
- Emergency response
- Personnel supervision and training.

Again it is stressed that personnel titles and assignments of activities and responsibilities differ somewhat from MODU to MODU. The assignments indicated appear to be typical (based on the study findings and industry review), but they are not universal.

Finally, the material presented here is generalized so as to be applicable to all types of MODU. In some cases, when it seemed essential for clarity, distinctions are made on the basis of MODU type and also propulsion mode.

Person-in-Charge of Move Functions. Tables S.8 and S.9 give an overview of what is done by the person-in-charge of MODU handling underway and of "moving on" (positioning the unit on location) and "moving off." The activities and responsibilities are all marine in nature. A division is made between self-propelled and towed modes of operation. On a self-propelled MODU, the person-in-charge (licensed unlimited Master) and his assistants perform the tasks of navigation, maneuvering, and collision avoidance. When a MODU is towed, a tug master has those responsibilities. Drill ships under tow are a special case; the ship Master may direct the tow as on a conventional ship. The task statements were written to include all of the requirements, even though they may be fulfilled by towing vessel personnel, because they are essential for marine safety.

TABLE S.8

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF THE PERSON-IN-CHARGE OF MODU-HANDLING UNDERWAY

Self-Propelled*	Towed
• Derives information from charts, tables and other navigational references to ascertain track-line and conditions along route	• Responsible for monitoring the security of tow wires**
• Takes readings from/monitors navigational instrumentation	• Responsible for communications with towing vessels
• Determines ranges to and bearings of aids to navigation; monitors communication equipment	• Responsible for monitoring MODU motions due to seaway and tow-line
• Plots course and speed	• Receives weather information and takes action as required to protect the MODU (e.g., adjusts jackup leg height, ballasts)
• Interprets collision avoidance data	• Responsible for operation of propulsive units in coordination with tugs when MODU is providing propulsion assistance
• Assesses severity of hazards	
• Makes decisions and conveys navigation orders to other control-room personnel to execute vessel control actions	
• Receives weather information and takes action as required to protect the MODU (e.g., adjusts jackup leg height, ballasts)	

* Not applicable to submersibles and floating drill barges.

** Responsibility shared with towing vessel personnel.

The term "person-in-charge" is used because of the number of different categories of personnel who may direct or advise in the operations. If the MODU has independent propulsion capability, the activities and responsibilities in Table S.8 belong to the licensed unlimited Master, even if such a MODU is towed. On drill ships, at least, the unlimited Master also fulfills the requirements shown in Table S.9. If the MODU does not have independent propulsion capability, a Master is still required to be onboard. He may hold a special industrial license or be unlicensed, as detailed in the preceding Table S.7. In those cases, the Master may be any of several regular MODU personnel, shore-based operations supervisors, or consultant-type personnel brought on for moves. The categories include Tool Pusher, Barge Engineer, Jack Technician, Marine Superintendent, Rig Mover, Barge Mover, and Towing Director. The Master may or may not be the key person on the MODU for towing operations and positioning. It appears to be most common for a team to be involved, led by the person most skilled and experienced in conducting moves.

These circumstances appear to have arisen from the special technology of the positioning systems. Getting a jackup, for example, on and off location requires unique skills, so experts have been developed for that job. The possible combinations of titles would make a complex presentation, which can be avoided by looking at what is involved in being in charge of the underway and positioning functions regardless of the titles individuals may have.

In Table S.9, activities and responsibilities specific to bottom-standing MODUs have been called out. The other requirements, at the level of detail at which they are stated in the table, are generally applicable.

Tool Pusher. The Tool Pusher is historically the head man on a drilling job and he is clearly the head man among the drilling contractor personnel on a MODU. There are typically higher level field supervisors who keep informed about what is taking place on the MODU and go aboard periodically or when some difficulty is encountered. However, such personnel are not onboard at all times.

The Tool Pusher is typically cognizant of all aspects of MODU operations on location (and often during moves as well), although other onboard supervisory personnel of the drilling contractor, and also specialists, may immediately direct the conduct of work in their areas of expertise (e.g., the Rig Maintenance Supervisor or Mechanic directs the operation and maintenance of the power plant; the Underwater Equipment Specialist directs the testing and installation of the blowout preventers).

TABLE S.9

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF THE PERSON-IN-CHARGE OF MOVING ON (POSITIONING THE UNIT ON LOCATION) AND MOVING OFF

General

- Responsible for survey of hull and machinery (moving off)
- Responsible for preparation of the MODU for transit in accordance with operations manual (moving off)
- Assures readiness for damage control and fire-fighting (moving off)
- Determines expected meteorological conditions and other environmental conditions (moving on/off)
- Responsible for the placement and retrieval of anchors and buoys (moving on/off)
- Responsible for adjustment of anchor line scope and tension (moving on)
- Ascertains intended drill hole position and maneuvering requirements (moving on)
- Directs tugs if MODU is towed (moving on/off)
- Directs anchor boats (moving on/off)
- Responsible for ballasting/deballasting operations
- Responsible for ascertaining proper trim condition draft for drilling

Specific to Jackup Drilling Units

- Prior to move, determines expected bottom conditions, water depth, maximum wind speeds and wave heights/periods at new location to ensure that design criteria are not exceeded and to determine the air gap above chart datum plane, the orientation of the unit, and the adequacy of bottom support
- Ensures that all machinery, piping and control systems, are fully operable before commencing raising or lowering operations
- Calculates loads to ensure level attitude (within 2 to 3 deg.) of upper hull as mat/legs come(s) free of bottom
- Has overall responsibility for jacking operations

Specific to Submersible Drilling Units

- Prior to move, determines expected bottom conditions, water depth, maximum wind speeds and wave heights/periods at new location to ensure that the submersible can be safely set on bottom.
- Ensures that all machinery, piping and control systems, are fully operable before commencing ballasting operations

Table S.10 shows the activities and responsibilities typical of a Tool Pusher on a mobile offshore drilling unit. They are categorized as primarily marine, industrial, emergency-related, or supervisory in nature. It is shown that the Tool Pusher's responsibilities are very broad.

TABLE S.10

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A TOOL PUSHER

Marine

- Responsible for the physical condition of the structure of the MODU, including physical repairs as permitted in the field
- Responsible for compliance with governmental regulations promulgated by U.S. Coast Guard, U.S. Geological Survey, state bodies (within state waters) and others in foreign waters
- Ensures that elevating or ballasting machinery (depending on MODU design type) is operable at all times
- Responsible for ensuring proper condition of all machinery attached to the MODU; includes maintenance, repair, overhaul, replacement
- Maintains daily log of all operations
- Responsible for proper transfer of materials and personnel between MODU and crew and supply vessels
- Responsible for maintaining radio communications and for compliance of all personnel with FCC regulations
- Receives weather information and takes action as required by operations manual
- Directs lowering of derrick or mast (on MODUs so equipped) in preparation for move
- On jackup MODUs, responsible for maintaining bottom loadings of footings and mats in accordance with operating manuals and/or instructions provided by supervisor

Industrial

- In charge of all drilling operations including spudding in, well control, stuck pipe, crooked hole correction, etc.; coordinates with the lease operator's onboard representative, usually called Drilling Superintendent or "Company Man"
- Responsible for compliance with governmental regulations promulgated by U.S. Coast Guard, U.S. Geological Survey, state bodies (within state waters) and others in foreign waters
- On MODUs that drill in the floating condition responsible for proper installation, monitoring and maintenance of the marine riser system and subsea blowout preventers. (Calls upon expertise of Underwater Equipment Specialist.)
- Responsible for ensuring proper condition of all machinery attached to the MODU, includes maintenance, repair, overhaul, replacement.
- Maintains daily log of all operations
- Responsible for maintaining radio communications and for compliance of all personnel with FCC regulations

Supervisory

- Ensures adequate logistic support including housekeeping and feeding, spare parts, personnel transfer, fuel, drill water, potable water, consumables such as drilling mud, chemicals, etc.
- Assigns duties to personnel
- Responsible for implementing on-the-job training of personnel
- Responsible for safety training and drills, emergency station assignments-all safety activities of personnel
- Responsible for performance of service personnel attached to the MODU, such as caterers, contract roustabouts, hole conditioners, cementers, etc.
- Make personnel recommendations and receives complaints; may have authority to hire and fire

Emergency

- Takes initiative to combat any emergency
- In charge of control of a threatened blowout
- Directs corrective action to prevent excessive listing or capsizing as a result of structural failure on location
- Directs preparation of the MODU for an impending hurricane or heavy weather

Barge Engineer and Watchstanders. Tables S.11 and S.12 show the kinds of work typically done by the personnel who carry out duties related to ballast system operation, mooring, and maintenance of stability of a floating MODU on location. The same personnel typically stand underway watch. The titles shown on the tables are characteristic of semisubmersible MODUs. All activities and responsibilities are marine- or emergency-related in nature or application (e.g., maintenance of marine equipment).

TABLE S.11

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A BARGE ENGINEER

Marine

- Responsible for maintaining the stability of the unit
- In charge of 2 to 3 barge watchstanders
- Calculates the center of gravity of the unit daily and ensures that it meets criteria established in the operating manual; advises Tool Pusher of corrective action to be taken, if necessary
- Responsible for mooring system readiness with Rig Maintenance Supervisor
- In charge of mooring and unmooring operations
- Maintains log of meteorological conditions, drilling unit response, watertight integrity, variable loadings (updates every 4 hours)
- Advises Tool Pusher of loading locations of all oncoming materials
- Directs placement of materials to maintain MODU attitude optimal for drilling
- In charge of personnel performing material handling (e.g., Roustabouts, Crane Operator, Welder
- Responsible for securing workboats to the MODU
- Maintains meteorological and barge motion instrumentation
- Conducts periodic survey of critical structural members utilizing visual, ultrasonic, and dye penetrant
- Responsible for on-the-job hull repairs
- Responsible for ensuring proper welding and repair procedures are followed
- Acts as hull technical advisor to Tool Pusher
- Prepares work lists for repairs to hull and hull machinery items beyond capability of unit personnel
- Responsible for maintaining compliance with governing rules of governmental agencies or classification societies
- Responsible for scheduling inspections by governmental agencies or classification societies

Supervisory

- In charge of 2 to 3 barge watchstanders
- Responsible for establishment of damage control and firefighting procedures and personnel assignments
- Responsible for ensuring proper welding and repair procedures are followed
- In charge of personnel performing material handling (e.g., Roustabout, Crane Operator, Welder)

Emergency

- Responsible for establishment of damage control and firefighting procedures and personnel assignments
- In charge of preparing non-drilling items for heavy weather survival and transit conditions and other heavy weather conditions under the direction of the Master or Tool Pusher and in accordance with the MODU operating manual

TABLE S.12

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A WATCHSTANDER

Marine

- Maintains the control room
- Reads and records variable loadings, unit motions, anchor tensions, etc.
- Inspects all underwater and vulnerable spaces at prescribed time intervals
- Assists Rig Maintenance Supervisor in the maintenance and minor repairing of mooring equipment, motion recording equipment
- Assists in nondestructive inspection of structure and welds
- Stands underway helm watch in self-propelled mode

Emergency

- Performs firefighting and damage control duties as assigned

TABLE S.13

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A RIG MAINTENANCE SUPERVISOR*

Marine

- Responsible for the operation and maintenance of all machinery, (other than jacking), and directs repair. Includes prime movers, jacking machinery, ballasting/deballasting equipment, service pumps, material handling systems, electrical systems, barge control systems, ventilation systems, galley systems, mooring systems, communication systems, meteorological systems, barge motion measuring systems, etc.
- In charge of maintaining all enclosed spaces.
- Responsible for loading and offloading of all materials and personnel. (On semisubmersibles, the Barge Engineer does this; on jackup MODUs it may be done by a Jack Technician.)
- In charge of the personnel performing material handling (e.g., roustabouts, crane operator, welder). (On semisubmersibles, the Barge Engineer does this; on jackup MODUs it may be done by a Jack Technician.)
- Responsible for securing work boats to the drilling unit. (On semisubmersibles, the Barge Engineer does this; on jackup MODUs it may be done by a Jack Technician.)
- On jackups, may perform inspections of critical structural members and prepare reports.
- Responsible for maintaining spare parts for all machinery.
- Responsible for preventive maintenance schedules and records.

Industrial

- Responsible for the operation and maintenance of all machinery, (other than jacking), and directs repair. Includes prime movers, jacking machinery, ballasting/deballasting equipment, service pumps, material handling systems, electrical systems, barge control systems, ventilation systems, galley systems, mooring systems, communication systems, meteorological systems, barge motion measuring systems, etc.
- In charge of maintaining all enclosed spaces.
- Responsible for maintaining spare parts for all machinery.
- Responsible for preventive maintenance schedules and records.

Supervisory

- In charge of Motormen and other personnel assisting in maintenance functions.
- In charge of the personnel performing material handling (e.g., roustabouts, crane operator, welder). (On semisubmersibles, the Barge Engineer does this; on jackup MODUs it may be done by a Jack Technician.)

Emergency

- In charge of preparing unit for heavy weather, survival and transit conditions under the supervision of Master or Tool Pusher and in accordance with the MODU operations manual. (On semisubmersible MODUs, Barge Engineer is usually in charge of preparation not related to drilling items. On all MODUs the Driller usually carries out the duties of preparing the well and drilling equipment with the assistance of the drilling crew.)
- In charge of damage control party.
- Directs firefighting in enclosed spaces.
- Generally, in charge of one means of abandonment.

* On some units, RMS duties are split between a mechanic and an electrician, with one designated as in charge. On semisubmersibles, and on jackups with silicon control rectifiers, an electrical maintenance supervisor is responsible for the operation, maintenance, and repair of electrical machinery. A shore-based pool of mechanics and electricians may be drawn upon for assistance as needed.

Machinery Plant Operations and Maintenance Personnel. Tables S.13 and S.14 summarize the supervisory-level duties related to the MODU machinery. The job categories used are Rig Maintenance Supervisor (RMS) and Electrical Maintenance Supervisor (EMS), which are not used by all drilling contractors. There is also variation in the machinery plant job categories on different MODUs owned by the same company, in some cases. However, the two categories named convey the general practice of having both a mechanical and electrical specialist onboard, one of whom is designated in charge. (Normally when there is an RMS, he will be in charge). The titles Rig Mechanic and Electrician are also common. As noted in Table S.14, an EMS (or Electrician) is usually among the onboard personnel when the MODU has relatively sophisticated electrical systems. MODUs that do not, and/or that operate on locations where shore-based support is readily and quickly available, may not have to keep an electrical specialist onboard at all times.

Some of the RMS and EMS duties were categorized as both marine and industrial. This is because the machinery plant serves both marine and industrial operations. The study found no significant difference in machinery plant requirements on location and during moves and no significant differences associated with the propulsion mode of the unit.

TABLE S.14

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF AN ELECTRICAL MAINTENANCE SUPERVISOR*

Industrial	Marine
• Responsible for the operation and maintenance of all electrial machinery	• Responsible for the operation and maintenance of all electrial machinery
• Responsible for maintaining and repairing radios and telex (when there is no radio operator), internal communications system, warning alarm systems, silicon control rectifier (SCR) systems, navigational lighting systems, obstruction lighting systems, emergency power systems, including batteries, and galley equipment	• Responsible for maintaining and repairing radios and telex (when there is no radio operator), internal communications system, warning alarm systems, silicon control rectifier (SCR) systems, navigational lighting systems, obstruction lighting systems, emergency power systems, including batteries, and galley equipment

* On jackups having silicon control rectifier (SCR) systems and generally semisubmersibles.

Table S.15 shows the kinds of work typically done by MODU Motormen. Basically, they stand watch in the machinery spaces and assist in the performance of the activities listed in Tables S.13 and S.14.

TABLE S.15

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A MOTORMAN

Marine	Industrial
• Stands operational watch in the engineroom and other machinery spaces.	• Stands operational watch in the engineroom and other machinery spaces.
	• Keeps Driller and Rig Maintenance Supervisor informed of suspected or actual malfunctioning of equipment.
	• May serve as a relief hand on the drilling floor as necessary.
	• Assists in direction and performance of preventive maintenance and repair of drilling machinery.

Drilling Personnel. All of the duties of drilling personnel are industrial in nature, except for emergency-related duties which may fall in both categories. One other exception is that drilling personnel may serve as hands in field transit operations under the direction of the person-in-charge, with the Driller acting as immediate supervisor of assigned tasks. Typical drilling personnel categories include Driller, Derrickman (sometimes titled Assistant Driller), Floor Hand (also typically called Roughneck). As shown in Table S.16, the Driller operates the automated drilling systems from his position at the drilling console and directly supervises the work of the drilling crew. He also takes charge of maintenance and repair of the drilling equipment and machinery, working with the Rig Maintenance Supervisor (or equivalent title) in this function. Other responsibilities are indicated in Table S.16. The duties of the lower level personnel involved in drilling operations are summarized in Tables S.17 and S.18.

TABLE S.16

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A DRILLER

Marine	Industrial
• May provide and supervise personnel in field transiting operations, under the direction of the person-in-charge.	• In charge of the men performing the actual drilling operations from his position at the driller's console. • Carries out the general instructions of the Tool Pusher in the plan for drilling the well. • Works with Rig Maintenance Supervisor in the repair and maintenance of drilling equipment and machinery. • Directs the handling of drilling materials from storage areas to drilling floor. • May assume duties of Tool Pusher if he is sick or injured.

Supervisory	Emergency
• In charge of the men performing the actual drilling operations from his position at the driller's console. • Directs the handling of drilling materials from storage areas to drilling floor.	• Directs one firefighting team in the event of a fire. • In charge of one abandonment means. • Under direction or general instructions of the supervisor, executes procedures to kill a threatened blowout. • Prepares well and drilling equipment for heavy weather and survival conditions.

TABLE S.17

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A DERRICKMAN
(All activities and responsibilities are industrial)

- Strings cables through pulleys and blocks to rig derrick equipment
- Cleans and oils pulleys, blocks, and cables of hoisting system
- From monkeyboard in derrick, guides drill pipe to/from storage rack fingers and latches/unlatches elevators when making up string and tripping in and out of borehole
- Weighs mud materials, mixes mud
- Operates mud pumps
- Monitors mud returns
- As experienced drilling crew member, may act as assistant driller
- In charge of repair of mud pumps.

TABLE S.18

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A FLOOR HAND
(All activities and responsibilities are industrial)

- Assists Driller in running drill string in and out of hole; assists in running casing strings
- Handles power tongs and spinning chains to tighten and disconnect sections of casing and drill pipe
- Assists Derrickman in mixing of drilling mud.
- Maintains drilling floor (e.g., racks tools, wipes up mud)
- Cleans tools and equipment
- Assists in maintenance/repair of drilling equipment as directed
- May assist Derrickman in rigging hoisting system.

Crane Operator. Table S.19 outlines the work of the Crane Operator. His responsibilities are primarily industrial or supervisory. He is often called the "Roustabout Pusher," supervising the material-handling and other general labor performed by those entry level personnel (see Table S.20). On MODUs that drill in the floating condition, the Crane Operator must recognize the need for proper placement of materials to maintain floating stability for optimum drilling, although he is supervised in fulfilling that requirement by a Barge Engineer (or equivalent personnel category), who has responsibility for floating unit stability on location.

TABLE S.19

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A CRANE OPERATOR

Marine	Industrial	Supervisory
• Operates crane to move materials, equipment and personnel to or from support vessels and to move heavy loads on unit.	• Operates crane to move materials, equipment and personnel to or from support vessels and to move heavy loads on unit. • Responsible for training and supervising roustabouts in sling selection, sling maintenance, wire rope maintenance and care, securing a load, loading and offloading procedures, etc. • Responsible for the material condition of all cranes.	• Responsible for training and supervising roustabouts in sling selection, sling maintenance, and care, securing a load, loading and offloading procedures, etc. • Generally, supervises hull maintenance work of roustabouts.

TABLE S.20

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF A ROUSTABOUT

Marine	Industrial
• Performs general labor as directed.	• Performs general labor as directed.
• Assists in loading, offloading, and moving equipment and materials onboard.	• Assists in loading, offloading, and moving equipment and materials onboard.
• Performs hull and other maintenance tasks as directed.	• Performs hull and other maintenance tasks as directed.

Underwater Equipment Specialist. This personnel category is unique to MODUs that drill in the floating condition. An equivalent title is Subsea Engineer. This person is a manufacturer-trained technician directly in charge of the special drilling equipment necessary on floaters. Table S.21 indicates his activities and responsibilities, all characterized as industrial in nature. The Underwater Equipment Specialist, along with the divers supervised by him, are typically under contract to the lease operator; they are the personnel support part of the subsea equipment package. Sometimes the drilling contractor subcontracts for this equipment and the supporting services, but that is less common than for the operator to furnish the package.

TABLE S.21

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF AN UNDERWATER EQUIPMENT SPECIALIST
(All activities and responsibilities are industrial)

- Directs the installation of the marine riser system for drilling from a floating unit, the subsea blowout preventer stack, the installation of television cameras for subsea inspections, and their disconnection or removal for a move off location.
- Conducts tests of blowout preventers before they are installed.
- Monitors the operation of underwater equipment to assure that it is functioning properly; notifies Tool Pusher of need for special check including the use of divers.
- Responsible for proper maintenance and repair of underwater equipment; requests additional technicians as needed.
- Repairs and overhauls as necessary the blowout preventers.
- Responsible for wellhead equipment, casing hangers, blowout preventer, risers, etc.

Emergency-Response Personnel. Emergency response potentially involves every individual on a MODU. In some of the preceding summary tables, emergency activities and responsibilities were stated; that was done when personnel in a certain category are typically in charge of a certain aspect of emergency response. When emergency activity was not shown, that does not mean that the personnel have no involvement; all do. The emergency-response task analysis sheets cover all MODU personnel without exception. Table S.22 gives a complete overview.

TABLE S.22

TYPICAL ACTIVITIES AND RESPONSIBILITIES OF PERSON-IN-CHARGE AND ASSISTING PERSONNEL IN EMERGENCY-RESPONSE SITUATIONS

Person-in-Charge	Assisting Personnel
PREVENT A THREATENED BLOWOUT	
• Interprets data obtained from equipment instruments or written or verbal reports to determine appropriate response	• Monitors instrumentation associated with the circulation system and well control system and records information as necessary
• Directs movement of assisting personnel	• Adds or mixes materials to weight up mud
• Monitors and interprets information on drill pipe and formation pressures	• Manipulates accessory equipment to control flow from well
• Alerts personnel to the severity of the situation	• Operates communications equipment and emergency-alarm equipment as necessary
• Operates controls of mud circulation system and well control system to kill well	• Observes mud flow at flow line and/or circulating system instrumentation providing data on flow from well
• Calculates mud densities required to kill well	
CONTAIN AND EXTINGUISH AN ONBOARD FIRE	
• Assesses type and severity of fire and capabilities/limitations of resources to determine best method to contain/extinguish fire	• Operates controls of fire extinguishing pumps and accessory firefighting equipment
• Directs assisting personnel in firefighting activities	• Operates communications equipment and emergency-alarm equipment as necessary
• Alerts personnel to the severity of the situation	• Inspects MODU spaces to assure safety of personnel
• Selects proper firefighting equipment.	• Provides first aid to victims
• Evaluates the progress of firefighting efforts to determine if additional assistance is needed or if MODU should be abandoned	
CONTROL FLOODING AND MAINTAIN STABILITY OF MODU (DAMAGE CONTROL)	
• Assesses source, cause, and extent of flooding to determine appropriate response	• Operates communications equipment and emergency-alarm equipment as necessary
• Directs personnel in efforts to stop and/or reduce entry of water into MODU	• Manually and/or automatically (operating hydraulic equipment) seals MODU spaces and openings
• Calculates amount, location, and sequence of ballast to counterflood MODU	• Shores up MODU structures to confine and prevent further flooding
• Monitors ballast system for status of flow and tank conditions	• Operates controls of bilge and/or ballast system to pump water overboard
• Evaluates the progress of the damage control activities to determine if additional assistance is needed or if MODU should be abandoned	• Inspects MODU spaces to assure safety of personnel
	• Provides first aid to victims
SHUT DOWN AND ABANDON MODU	
• Acts as liaison with shoreside personnel	• Secures and/or stores loose equipment, tools, materials, etc., prior to abandonment
• Directs activities of crew to prepare hole, derrick, and MODU in general for temporary abandonment	• Manipulates controls of emergency generators, navigation lights, and other equipment to be set or adjusted prior to abandonment
• Assesses emergency conditions to select safest, most expeditious means of abandonment	• Provides first aid to victims
• Directs movement/transfer of personnel in rescue craft	• Inspects MODU spaces to assure safety of personnel

TRAINING NEEDS

The analysis specified training content for each task in each functional grouping of MODU operational requirements. Thus the data created in this study make a compendium of detailed training needs of MODU personnel related directly to the tasks they may be asked to do. It is believed that this compendium would be applied most appropriately by the drilling companies, their operations supervisors and training personnel.

For the study team, the development of the tasks specifications and corresponding training content was an educational process that enabled us to assess current training practices and to make recommendations that are general enough to be applicable industry-wide. The task analysis data also provide a reference for evaluation of the study recommendations.

The summary tables of typical activities and responsibilities by personnel category imply the kinds of training needed in the various functional areas and no further summarization is presented here. Training content summaries are explicitly provided in the individual reports on the MODU design types.

EXPERIENCE NEEDS

The analysis indicated that experience is required for competency in most of the tasks of MODU operations. The task analysis does not, however, yield absolute values for the appropriate term of the experience. It would be possible to establish norms for time required to learn tasks by documenting the actual times for samples of personnel. There still remains the problem of integrating task learning times to come up with a total time for competency in a given assignment that includes a number of interrelated tasks. In any event such an endeavor was beyond the scope of this study. Even if this were done, it is important to recognize that real experience needs depend on individual capabilities for learning and for helping others learn on the job. Ideally the variations in those capabilities can be allowed for so that the amount of experience required is the amount it takes the individual in a particular work organization to learn to do the tasks assigned to him. Under ideal conditions, the adequacy of experience should be judged on the basis of performance standards.

Nevertheless, although it is believed that any absolute values for experience requirements are questionable, it is recognized that for various administrative purposes some quantities may have to be set. When they are set, the term of experience is a matter of judgment. Such judgments are optimally based on understanding of the work requirements and knowledge of typical amounts of time it has taken people to learn to do given types of work in the past. The task analysis was performed to satisfy the former. To satisfy the latter we tried to gain insight by talking with MODU personnel and also called upon the knowledge of industry managers.

CURRENT PRACTICES IN PERSONNEL SELECTION AND TRAINING

This study was designed to provide information needed to assess whether personnel are suitably trained and experienced to avoid marine casualties in MODU operations. Three kinds of information were sought: information about MODU design and equipment, work system organization, and operations; detailed information about the tasks of MODU operation and the kinds of skills and knowledge the tasks require; and finally, the methods used by drilling companies to assure themselves of competent personnel. This section of the report presents the information obtained in the last of these three categories.

A survey of current practices and trends in the selection and training of MODU personnel was performed to determine (a) whether the present system appears to attend adequately to marine safety requirements and (b) how any gaps might be closed effectively and as conveniently as possible for all concerned. It was believed that, should any new personnel qualification requirements be needed, they should be designed to fit within the existing system of selecting and training personnel as smoothly as possible, so as not to cause disruption and place unnecessary barriers between competent personnel and their present jobs or job opportunities. In addition any requirements should be designed so as to avoid an unworkable oversight and enforcement burden.

We could not, within the scope of this study, take a statistical approach to personnel selection and training. We could not, for example, document the years of work in various categories and the training experiences of samples of personnel. Information was obtained more informally, in the following ways:

- Discussions with operations supervisors and management personnel during field visits and by telephone.
- Questions asked of onboard personnel working in all functional areas and at all levels during the visits to operating MODUs.
- Review of training materials prepared by the individual companies, industry organizations (the International Association of Drilling Contractors, the American Petroleum Institute) and universities.

The information from those sources is brought together here in a generally applicable description of personnel practices. It is believed that this material represents the typical with good fidelity. However, it should be noted that personnel practices are not standardized industry wide. Undoubtedly, each company, if asked to detail their personnel selection and training practices, would qualify some of the statements made here.

Selection Practices

Offshore drilling is a unique operation. Review of the task analysis results in Volumes II and III will demonstrate that experience in other fields (excluding land drilling) does not in itself prepare people for work on a MODU and does not necessarily make one candidate preferred over another. Certain types of experience and/or training would appear to make it easier to learn certain MODU tasks, other factors being equal, but the industry reports that, for the most part, they have not found it desirable to establish fixed prerequisites for personnel who have never before worked on a MODU. There are a few exceptions to this: Masters of independent, self-propelled MODUs, and sometimes Mates, must have maritime experience and training as required to obtain the necessary Coast Guard license. Welders and Crane Operators typically have worked in those capacities outside the drilling industry, although MODU personnel with no prior experience or training in welding or heavy equipment operation may be trained for those jobs on a MODU. Personnel who have had experience in land drilling or other offshore drilling operations (such as well workover or platform drilling) may be hired for upper level drilling functions on MODUs and go to work after receiving orientation to MODU characteristics. Mechanical operations and maintenance personnel may go into onboard positions from shore-based pools.

With the above general exceptions (and possibly other unique exception cases) to our knowledge no one has ever been hired for any upper level MODU position on the basis of experience gained outside the offshore drilling industry or on the strength of academic training. Historically, offshore drilling is a field in which people work up from the bottom, learning on the job.

Based on the task analysis and observations of the work system, it is believed that this is not simply an historical circumstance but a necessity. The combination of unique systems and equipment, unique tasks, teamwork requirements, and the working conditions creates a total system that has no counterpart. Not only is on the job experience and training necessary for effective task performance, it is necessary for an individual and the company to determine whether he can adapt to the working conditions, which include strenuous physical exertion, exposure to the environment, confinement within relatively small, isolated facilities, separation from family and outside friends, and a society that is preoccupied with mission and does not easily accommodate pursuit of other interests (at least while onboard, if ever depending on the rotation). It would appear difficult for people who do not want to invest a great deal of themselves in their work to remain in offshore drilling. Thus, it seems to take a special kind of person to fit in; and here, where personnel are often dependent on each other for their physical safety, fitting in is even more important than in other small, closed work systems.

New personnel with no experience in the drilling industry are typically brought on as Roustabouts or as Floor Hands. Roustabouts particularly are general purpose laborers who assist in virtually all MODU functions. Wherever they assist, they have an opportunity to learn and move up. Floor Hands are members of the crew on the drilling floor, so perhaps they are more likely to progress in drilling functions. However, they can expect to be called on to assist in other areas as needs arise, and given interest and aptitude can reasonably aspire to work in other areas. This kind of flexibility is possible and necessary on a MODU because it is a small, closed work system in which the available personnel may have to do what needs to be done without help from outside.

A fairly recent trend is to recruit new personnel with college level engineering training (mechanical, electrical, petroleum, marine, etc.,). Special programs have been devised in which such individuals are rotated through work assignments in the various functional areas for relatively short periods. The entry level jobs of Roustabouts and Floor Hands are included. This work experience is accompanied by requirements to complete independent study courses such as developed by the Petroleum Extension Service at the University of Texas at Austin. The selection of engineering graduates for these programs reflects the orientation of the work. However, at least one company has involved liberal arts graduates in such a program with comparatively good success.[3] The intent of such programs is to attract and hold college graduates by accelerating the apprenticeship process and to develop supervisory level personnel and potential managers quickly. The impetus has come from the growth of the industry and individual companies and the increase in overseas drilling. For some overseas operations it has been necessary to train citizens of the countries involved to work at all levels of MODU operations.

The industry also reports no fixed prerequisites, such as a certain period of time in a job category, or completion of an exam, for hiring experienced personnel or promoting from within. Decisions are based on individual job performance.

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[3] See paper by Mr. LeJeune Wilson, SEDCO, Inc., titled "Personnel Recruitment and Training for Large Offshore Drilling Operations--A Case History," in Proceedings of the 9th Annual Offshore Technology Conference, Houston, Texas, May 1977. Paper No. 3014, Vol. 4, pages 383-388.

In general, the selection and promotion system can be characterized as highly flexible and personal. This is possible and appropriate for several reasons:

- Drilling companies are small or their operations management is decentralized. It was observed that field supervisors who do not remain onboard at all times, work very closely with onboard supervisors and typically know every onboard employee. Hiring and promotions are typically handled at the field operations level and sometimes by MODU supervisors themselves, although applicants may be sent out by headquarters.

- Onboard supervision is personal and close. Supervisors work side by side with their subordinates. There are no office jobs on a MODU in which personnel remain removed from operations. Thus onboard supervisors are intimately familiar with personnel capabilities and are in a position to provide personal instruction in task performance.

- Tasks are by and large tangible and their outcomes immediately observable. Each function involves a well-structured set of tasks, so that competency can be determined by direct observation and questioning. It appears that in most cases, written testing alone would not be an adequate means of assessing competency since most of the tasks involve performance of physical actions. The task analysis data in Volumes II and III make this evident. Written tests could be used to measure certain kinds of job knowledge and independent study packages used on MODUs include short tests. However, it should be remembered that many MODU personnel do not have an academic orientation and may not do well on written tests despite excellent competency in the performance of their work.

- This is not an industry that receives a superfluity of job applicants. Thus, one of the primary purposes of hiring prerequisites--to provide impartial criteria for turning away applicants--is irrelevant. With respect to promotion prerequisites, we believe it is accurate to say that the industry does not see value in setting up intermediate measures of capability

for promotion, such as time in a lower level job category or test performance, when, as is believed, capability can be directly observed. One reason for standardizing qualifications for advancement is to reduce the demands on supervisors in large organizations wherein personal knowledge of every employee's performance is difficult or impossible to achieve. Another reason is to reduce disputes about promotion equity. The offshore drilling industry does not appear to have difficulties in either area.

- For the most part, needs for additional personnel in various categories can be anticipated soon enough for planning to meet those needs. A new MODU takes a long time to build, so that normally by the time it is ready, personnel can be prepared for promotion to fill the additional openings and new entry level personnel recruited. Expansion by acquisition also does not normally happen overnight. Frequently, when acquisitions are made, personnel are given an opportunity to join the acquiring company.

- Offshore drilling is a relatively small industry, with substantial contact between companies, so that when personnel make inter-company moves their job performance capabilities may be checked on a personal basis.

Examples of MODU Personnel Progressions. There are two basic progressions: the drilling progression and the machinery plant operations and maintenance progression. Figures S.11 and S.12, presented on pages 34 and 35, illustrate the paths. Hopefully, they also illustrate that neither progression is rigid. The lower level personnel are typically used in more than one mode of operation or support. Wherever an individual has an opportunity to observe and assist, he has an opportunity to more up.

It will be noted that a marine progression is not so clearly defined. This seems to be because marine functions have been largely handled by specialists not among the regular MODU personnel. There is a marine-oriented mini-progression made up of the job categories of semisubmersible Barge Engineer and Watchstanders.

To clarify how personnel may move up in MODU occupations, examples are given for the personnel categories for which typical activites and responsibilities were presented in Tables S.8 through S.21.

Persons in Charge of Move Functions. Masters holding unlimited conventional licenses come into MODU service with Maritime Academy (or possibly Navy training) and extensive experience in ship handling. Drilling contractors provide orientation when they hire such personnel to acquaint them with offshore drilling operations, the organizational structure and MODU characteristics.

On MODUs without independent propulsion capability, underway operations are directed by towing operator personnel. There is MODU Master, either unlicensed or holding a special industrial license (the requirement varies with the distance of the move as shown in Table S.7); however, the role of this kind of Master on a towed MODU is limited. The navigational decisions rest with the tug/towboat captain. It was beyond the scope of this study to investigate skill acquisition and personnel progression in the offshore towing industry.

The other various specialists may come from the merchant marine, from the towing industry, from drilling operations or other backgrounds. Their critical expertise is not in conventional navigation but in the positioning systems and other characteristics (such as deck loading) unique to MODUs. These specialists acquire their expertise by assisting and observing in moves, studying equipment specifications and operating the systems. They may receive manufacturer training (in the principles and operation of jacking systems, for example).

When a new MODU is built, drilling contractor operations supervisors are closely involved in the various stages of design and construction, and are on site at the shipyard when the finishing is done and equipment installed. Frequently the Tool Pusher and other onboard supervisory personnel (e.g., the Barge Engineer, Rig Maintenance Supervisor) are on-site during the completion of the MODU. Their business is to become intimately familiar with the new unit and its systems. These people typically have leading roles in new unit moves (and in the first drilling job). Thereafter, they train others in move functions as well as other aspects of unit operations.

Tool Pusher. Tool Pushers come up through the ranks of the drilling personnel. They may have worked in other functional areas, but no case is known of a Tool Pusher who has not been a Driller and before that held some lower level position in the drilling crew. A common case is for a Tool Pusher to have made his entire career in offshore drilling, entering the field as a Floor Hand or Roustabout and working up from there. The developmental training is received on the job, augmented by special courses such as in blowout prevention. It is also common for drilling personnel to switch from land to offshore drilling at various stages in the progression. It appears that Tool Pushers from land operations may become MODU Tool Pushers fairly quickly. They are given an orientation to offshore operations that includes time on a MODU and may be provided temporary support on their assigned MODUs. Other

kinds of offshore operations, such as well workover and completion, have also been a source of MODU Tool Pushers according to the drilling company personnel contacted in this study.

As indicated by the foregoing, the Tool Pusher's special technical expertise is in the area of drilling. However, based on the interviews conducted in this study, Tool Pushers may be said in general to need and to possess broad knowledge of all MODU systems and functions. It was noted in the field survey that Tool Pushers tend to remain with one type of MODU (e.g. ship, jackup) and even on the same MODU; thus they become extremely knowledgeable of the characteristics of a particular MODU type or a particular MODU. Transfers between MODUs that drill in the floating condition and bottom-supported types are least common, although they certainly occur.

Barge Engineer. Like other MODU personnel, Barge Engineers acquire their expertise primarily through on-the-job training. Characteristically, a Barge Engineer has served as a Watchstander. Barge Engineers may partake of manufacturer-supplied training on ballasting systems. Some Barge Engineers have had maritime experience prior to entering the field of mobile offshore drilling; others have not.

Machinery Plant Operations and Maintenance Personnel. There is a potential progression here from an entry level job assignment such as Roustabout to Motorman to Mechanic, Electrician or Rig Maintenance Supervisor (or equivalent titles). Shore-based mechanical and electrical personnel may also fill openings for Motorman, Mechanics EMS, RMS, etc. Personnel in this category, as in the others, were found to have varied backgrounds, including agriculture, military service, marine engineering, construction, etc. The drilling companies indicated that they do not have prerequisites for entry level jobs, although previous experience or training in mechanical or electrical repair is desirable. Once a person is hired, advancement is determined by job performance and operational needs. Training courses are provided as discussed later.

Drilling Personnel. The drilling progression is from Floor Hand to Derrickman to Driller to Tool Pusher. Personnel may be hired as Floor Hands or move up to the floor after working as Roustabouts. Some companies have designated Assistant Driller and Assistant Tool Pusher positions. It appears that where there are no Assistant titles, personnel are treated as assistants when they are identified as candidates for advancement. Training is on the job. Basic pre-work training courses for entry level personnel have been devised, but they are not universally used. Personnel who have drilling experience may be hired at levels above the entry level. The only experience that really counts here is drilling experience.

Crane Operator. It is common for Crane Operators on MODUs to have worked as crane operators on land. There is a Crane Service School, and MODU personnel without prior experience in crane or other heavy equipment operation could be trained for the job. Roustabouts work under the direction of the Crane Operator in loading/offloading and in moving equipment onboard, so there is a potential progression there.

Training Practices

Training and experience are highly interrelated in this industry, as indicated in the preceding discussion of personnel selection. Training is largely provided by the industry itself, and largely provided on the job, because of the unique nature of MODU operations.

There are variations in the degree of centralized management and sophistication of training materials and methods; however, there appears to be a trend toward increasing sophistication as might be expected to accompany industry growth and advances in offshore drilling technology.

The training system might be characterized as an informal apprenticeship system. We say "informal" because there are no set time periods of apprenticeship, and no one is called an apprentice. Neither is skill mastery necessarily accompanied by any change in status other than personal recognition. Status changes occur as job openings occur. The special apprentice type programs designed for new personnel with formal engineering education are accelerated and more structured versions of the system used for MODU personnel in general.

Most companies seem to be working with onboard supervisors to increase their sensitivity to training needs and to improve training methods. Self-instruction materials such as the University of Texas at Austin PETEX (Petroleum Extension Service) "Home Study Course" are commonly provided onboard and management promotes work-study. (Completion of self-instruction packages is required of personnel involved in the special accelerated apprenticeship programs.) Videotape training systems have also been introduced.

Various schools/courses are provided by the drilling companies, by colleges and universities and by equipment manufacturers. The International Association of Drilling Contractors (IADC) and the American Petroleum Institute (API) have been active in developing curricula and materials. Schools/courses are described in Table S.23.

TABLE S.23

OVERVIEW OF SCHOOLS/COURSES USED BY MODU PERSONNEL

Functional Category	Description of School/Course
Marine	—Radar observer —Able seaman/tankerman —Acoustic position reference system —Marine licensing (in-house, tutorial basis)
Mechanical and electrical operations and maintenance	—Engine repair —Mechanical components and support systems repair —EMD engines: operation, maintenance and troubleshooting —Governors and controls —Water distillation unit operation and maintenance —Fundamentals of electricity and electronics —Basic AC power system —Electrical equipment maintenance and repair —SCR controls; SCR drive system
Drilling and related functions	—Elementary/basic drilling —Basic drilling, offshore operations —Entry level floorman training —School for Tool Pushers and Drillers —Advanced drilling engineering —Blowout prevention —Wireline functions —Drilling mud —Crane service school —Subsea TV equipment maintenance and operation —Motion compensator and tensioners —Hydraulic subsea equipment —Blowout prevention systems
Emergency	—Lifeboatman training —Fire fighting —Damage control —Well control procedures
Supervisory	—Fundamentals of supervision —Safety training for field level supervisors —Supervisor's conference on accident prevention

CONCLUSIONS

There were three basic issues to be dealt with in drawing conclusions from the mass of information compiled during this study:

- What are the critical functions with respect to marine safety?
- Is the typical allocation of personnel responsibilities the best possible allocation for assuring that marine safety requirements will be met?
- Do the existing practices provide reasonable assurance that MODU personnel have the skills and knowledge they need to meet the marine safety requirements in MODU operations?

The conclusions reached and the reasons for them are presented below. These conclusions shaped the recommendations made in the final section of this volume.

Critical Functions with Respect to Marine Safety

The critical functions were judged by the potential for deficiencies in task performance to result in loss of integrity as a marine unit and also by sensitivity to the effects of variable environmental conditions. The critical functions were identified as:

- Navigation to or from the drilling site
- Positioning on the drilling site (moving on/off location)
- Emergency response.

The casualty history underlies these choices of critical functions. Table S.3, presented on page 30, shows that approximately two-thirds of the 98 MODU casualties that occurred from January 1955 through June 1976 and resulted in extensive damage ($500,000 or more) were marine in origin. They were casualties in towing and in moving on or off location, plus casualties attributed to severe storms. Of the casualties identified as industrial in origin, approximately two-thirds were well blowouts. No further description was available of the serious casualties of industrial origin that were not blowouts. It appears, however, that short of a blowout or fire, no purely industrial operation is likely to result in loss of unit integrity. (Blowouts and fires were treated as emergency conditions in this study.)

Allocation of Personnel Responsibilities for Marine Safety

As shown in Tables S.8 and S.9, and as discussed in the associated text (pages 38 through 41), various specialists direct move-related functions. Often some or all of those specialists are not regular employees of the drilling contractor, and rarely are any of them among the MODU personnel on location. (Masters of self-propelled MODUs are typically an exception, staying with the unit on location.) There could be one individual conducting

the transit and another directing positioning at the drill site, while the Tool Pusher is in charge on location. These people may work effectively as a team; however, the division of authority and responsibility appears to open possibilities for confusion, conflict, and loss of control.

The use of move specialists is fine, but they are on the MODU for relatively short periods of time and may never have been on the particular MODU prior to the move. Thus they may need both information and leadership assistance from an individual who knows the unique characteristics of the MODU and the capabilities of regular personnel who may be called upon to assist in move-related tasks.

Further, it appears that greater responsibility of regular MODU personnel in move operations would make them more sensitive to the marine environment and would lead them to see marine functions more clearly as part of the total system rather than the business of specialists. This is particularly important should an emergency arise, including threatening weather, while the MODU is on location. It could happen that no one with adequate understanding of marine hazards and safety requirements is available when an emergency or potential emergency arises while the unit is on location.

We believe it is fundamental to marine safety in MODU operations that all concerned should recognize that a MODU is a single entity. It has a dual nature as a marine industrial unit; but it is not partly or at times a vessel and partly or at times a drilling unit. It appears that relatively minor adjustments in the division of responsibilities could promote better integration of the marine and industrial aspects of MODU operations.

<u>Personnel Practices as Related to Marine Safety</u>

As stated in the preceding section responsibility for the conduct of moves is given to specialists. Based on industry reports, there are no fixed criteria for the selection and training of these personnel except for Masters of self-propelled MODUs, who must have merchant marine credentials, and in some instances Mates, who must have merchant marine credentials or a special industrial license. There must be a Master of some kind on a MODU at all times and this individual may be required to hold a special industrial license if not an unlimited conventional Master's license. However, this Master is not necessarily the person who actually directs underway operations and moves on/off the drilling site.

Again, the Master of a self-propelled MODU is an exception. Other personnel are chosen for key roles in moves on the basis of experience in MODU moves, which is acquired on an apprentice type basis. Such personnel may receive manufacturer training in the operation of jacking systems on self-elevating MODUs or ballasting systems on semisubmersibles. Some personnel have merchant marine backgrounds, others do not. The typical qualifications of towing vessel personnel responsible for towing arrangements and safe navigation underway are unknown since it was not within the scope of this study to look into their qualifications.

Discussions with industry managers and operating personnel, including move specialists in the employ of two drilling contractors, indicated that the move specialists are indeed capable and experienced. It is reasonable to assume that a drilling contractor would not entrust a multi-million dollar MODU to a person or persons who had not demonstrated competency. Nevertheless, it appears that the qualifications could be tightened up.

The task analysis showed that navigating a MODU and moving a MODU on/off location are jobs for which there appears to be no equivalent experience. The cases of drill ships and floating drill barges may be excepted since they are like conventional vessels except for deck loading, so that experience may be expected to transfer. Thus it is concluded that there is no way to learn to do this job other than the established apprentice-type system. It would certainly be desirable to have a simulator trainer on which personnel could gain experience in dealing with unusual hazards and emergencies. However, such a resource does not exist.

It should also be noted that the industry's present formal training resources do not cover seamanship. Since not all move specialists come from merchant marine backgrounds, this appears to be a training gap. It cannot be assumed that training in stability, seakeeping, interpretation of weather data will be received on the job since the mentors may not have been trained in those areas.

Finally, the task analysis pointed up significant differences in move functions on the basis of MODU type—in particular, differences in positioning requirements and hazards and the differences in requirements for response to potential hazards underway. These differences are reviewed in this volume in the descriptions of MODU types and are detailed in the task analysis sheets in Volume II, Section II (page 17 ff for jackups, page 25 ff for submersibles, page 35 ff for semisubmersibles, page 46 ff for drill ships, and page 56 ff for floating drill barges). According to industry reports experience in moving a MODU of the specific type is not necessarily required under current practice.

It should be noted that training is provided on an in-house, tutorial basis to enable personnel to qualify for the special industrial licenses now required by the U.S. Coast Guard. Comparison of the licensing requirements with the task requirements for MODU move functions would indicate the adequacy of the licensing criteria as definers of seamanship training for persons directing MODU move functions.

Training for emergency response is another area in which gaps were identified. These are in the areas of abandonment, fire fighting, and stability maintenance and damage control. Blowouts are excluded. The reasons for that exclusion are explained first. Then the conclusions concerning the other emergency areas are explained.

A great deal of effort has gone into blowout prevention. The developments include advances in blowout prevention equipment; the use of manufacturer-trained technicians to direct installation, testing, monitoring and maintenance of that equipment; and the widespread use of well control schools. Those

developments are in the right direction and no additional steps are recommended on the basis of this study. With regard to the schools, the study team found that the curricula include coverage of the geophysical conditions, how drilling practices can aggravate those conditions and how to avoid doing so, and detailed procedures for well control; both the theoretical and practical sides of the problem are being covered. The use of simulators in well control training is a great advance.

Training for other types of emergency could be improved by the creation of opportunities for hands-on response to these relatively rare events. Training in fire fighting and abandonment procedures is currently provided onboard. This training includes presentations by onboard supervisors and visiting safety officers, discussion, and drills in which personnel go to their duty stations. Such exercises are helpful, but remote from what may be required in a real emergency. Few personnel get practice in combatting a fire, in launching primary lifesaving equipment (e.g., a lifeboat or enclosed spherical survival capsule) and operating it to get away from the MODU, or in dealing with equipment failures.

There are fire fighting schools available (see Table S.23) but according to the information gathered in this study, not all or even the majority of drilling companies make a practice of sending even the onboard supervisors to a fire fighting school. For abandonment there are schools where MODU personnel can qualify as Lifeboatmen, but these schools do not cover survival capsules widely in use on MODUs. The statements about use of lifeboatman schools are as for fire fighting schools. In some cases LSAs may be launched during onboard drills; however, this is not always practical. Even when they are launched, again it appears that few personnel gain experience in operating releasing mechanisms, using special features (e.g., the sprinkling system of a survival capsule), getting away, and transferring from an LSA to a rescue vessel.

In general, it appears that design features, operating instructions, operability of LSAs, and their placement on the MODU need to be examined in greater detail from a human engineering perspective and taking into account characteristics of MODU personnel. Questions about the stability of survival capsules were also raised during the study.

Some drilling companies send personnel to maritime damage control schools. Again, however, this is not a universal practice. It also appears that instruction in this area should, but presently does not, address specific MODU type. It should be noted that stability is a potential problem area of unique character for self-elevating MODUs both underway and on location. (In the latter case, we refer to the problems of settling/tipping and leg failure.)

In general, interpretation of weather data and seakeeping and stability characteristics of MODUs are areas in which formal training appears to be insufficient and opportunities for on-the-job training uncertain, except perhaps when a conventionally-licensed Master is onboard. Even in that case, depending on the MODU type and/or the degree to which the Master has an active role on station, there may be a need for additional training for other personnel to assure an adequate onboard capability to respond to emergency or potential emergency conditions that may affect the stability of the MODU.

Other Conclusions

MODU machinery plant personnel are affected by the current marine manning requirements as they pertain to Engineers. More specifically, the requirements include a special industrial license. In order to qualify for that license, candidates must pass a test which includes both electrical and mechanical systems. This is a marine safety requirement which the findings of this study do not support for two reasons.

First, the task analysis showed no significant difference in the requirements for machinery plant operations and maintenance during moves versus on location. Propulsion units are another load on the prime mover, but do not result in different operational requirements. Thus the personnel who operate the plant on location should be equally well qualified to do the job on a move.

Second, but perhaps more important, MODUs differ from conventional vessels organizationally as well as mechanically. Both mechanics and electricians are employed by drilling companies, either onboard or as shore-based support, whereas ship engineers meet both mechanical and electrical requirements. The primary reason for this difference is that conventional ship electrical requirements are more straightforward than MODU requirements related to the drilling systems. Thus MODUs use electrical specialists. It is believed that any qualification requirements for MODU mechanical and electrical personnel should reflect the division of responsibility.

RECOMMENDATIONS

It should be noted that some of the drilling companies already fulfill the intent of some recommendations through existing policies. Unfortunately, it is not possible to acknowledge exemplary cases and propose requirements on a company-by-company basis. In general, it is believed that the recommendations made should be recognized as pertinent and useful industry wide.

Experience requirements are among the recommendations. The specific numbers are order-of-magnitude indicators judged to be appropriate and feasible based on the study of MODU operations. The numbers are presented as approximations, not as absolutes.

Figure S.13 is an overview of specific recommendations as to personnel qualifications requirements. Discussion of those recommendations follows the figure.

PERSON-IN-CHARGE, ALL CONDITIONS: TOOL PUSHER

REQUIREMENTS

- 2 consecutive years of experience on MODU(s), within past 5 years, as Assistant Tool Pusher, Driller, Rig Maintenance Supervisor, Barge Engineer or equivalent supervisory position a/
- Must have been on board for a minimum of 2 off-station and 2 on-station evolutions b/ on the type of MODU on which assigned as Tool Pusher

OR

- 1 year experience as Tool Pusher (offshore or on land) or 3 years drilling experience in a supervisory capacity on land
- Offshore orientation (if no offshore experience)
- On board for at least 2 off-station and 2 on-station evolutions on the type of MODU to which assigned as Tool Pusher

MODU HANDLER, SELF-PROPELLED MOVES: MASTER, UNLIMITED LICENSE

REQUIREMENTS

License endorsed for MODU type based on following:

Jack-Up / Semisubmersible / Submersible c/ — On board MODU of given type for minimum of 3 moves, at least 1 of which is self-propelled

Drill Ship / Floating Drill Barge — Certification by drilling company

MODU HANDLER, TOWED/TOWED PROPULSION-ASSIST MOVES:
MAY BE MASTER, UNLIMITED LICENSE; RIG MOVER (OR EQUIVALENT); TOOL PUSHER; BARGE ENGINEER (OR EQUIVALENT) d/

REQUIREMENTS: MASTER

License endorsed for MODU type based on following:

Jack-Up / Semisubmersible / Submersible — On board MODU of given type for minimum of 3 moves, at least 1 of which is towed/towed-prop. assist

Drill Ship / Floating Drill Barge — Certification by drilling company

REQUIREMENTS: RIG MOVER (OR EQUIVALENT)

Qualified for MODU type by following:

- On board MODU of given type for at least 3 towed/towed prop.-assist moves
- Demonstration of knowledge of marine environment, seamanship (e.g., by exam or successful course completion)

REQUIREMENTS: TOOL PUSHER, BARGE ENGINEER (OR EQUIVALENT)

Qualified for MODU class e/ by following:

- On board MODU of given class for at least 3 towed/towed prop.-assist move evolutions f/
- Demonstration of knowledge of marine environment, seamanship (e.g., by exam or successful course completion)

EMERGENCY RESPONSE PERSONNEL: FIRE FIGHTING AND MODU ABANDONMENT

REQUIREMENTS: ALL PERSONNEL (INCLUDING CATERING PERSONNEL)

Indoctrination in fire fighting and abandonment methods and procedures (fire fighting agents for different types of fires; how to operate fire equipment and life saving appliances on the particular unit; fire/lifeboat stations and duty assignments, etc.) through written materials, on board presentations and on board drills

REQUIREMENTS: ALL EXCEPT ENTRY-LEVEL PERSONNEL g/

Satisfactory completion of hands-on training in fire fighting and in the operation of the various life saving appliances

EMERGENCY RESPONSE PERSONNEL: DAMAGE CONTROL SUPERVISION

REQUIREMENTS: TOOL PUSHER, RIG MAINTENANCE SUPERVISOR, BARGE ENGINEER, OR EQUIVALENT

Satisfactory completion of training for MODU type, in stability and seakeeping characteristics under emergency/potential emergency conditions and in procedures for maintenance of stability including damaged stability

NOTES:

a/ Years of experience are calendar years of regular duty with the normal rotation.

b/ "Off-station/on-station evolution": Positioning, jacking, ballasting, anchor handling – as required, depending on MODU type, to get into position for engagement of drilling equipment or to move on or off location.

c/ Presently, no submersible has independent propulsion capability.

d/ The Barge Engineer (or equivalent job category) is responsible for ballasting operations, maintenance of trim and stability condition on station on semisubmersible MODUs.

e/ "MODU class": MODUs of the same hull form and essentially the same design characteristics although not necessarily identical in every respect (e.g., some differences in dimensions, equipment)

f/ "Move evolution": includes getting off station, transit, getting on station.

g/ These personnel are excluded from the requirement because turnover makes sending them to school impracticable.

FIGURE S.13. RECOMMENDED TRAINING AND EXPERIENCE REQUIREMENTS FOR MODU PERSONNEL

Central, Continuous Authority

The apparent potential for difficulties arising from division of responsibility and authority for different operating modes and within the move-related modes could be minimized by making a single individual clearly in charge of the MODU at all times. This is not intended to rule out the use of specialists in directing as well as assisting roles. It is intended to assure continuity and control through a central authority who knows the MODU characteristics and its personnel and who has an interest in all aspects of MODU operations.

Tool Pusher as Person-in-Charge, All Conditions

It is recommended that this person in charge be the Tool Pusher. Because of the predominance of the industrial characteristics and mission of a MODU, it does not appear appropriate to consider any other choice. The Tool Pusher is clearly in charge on location. Onboard personnel apparently look to him as in charge at all times; thus he is the person who may be expected to exercise authority most effectively. He may call upon specialists for assistance, but he should retain overall responsibility regardless of the operating mode. As shown in the preceding tables of activities and responsibilities, the Tool Pusher's range is greater than that of any other personnel category. Thus, he should be the most broadly knowledgeable of MODU characteristics and operating constraints as well as personnel characteristics.

Tool Pusher Qualifications to Act as Person-in-Charge, All Conditions

The Tool Pusher needs to be prepared for the role of person in charge in all modes of operation by a combination of training and experience. It is believed that the experience and knowledge of many of the present Tool Pushers have prepared them to take on that role with small additional effort—in some instances perhaps none. However, certain qualification requirements are recommended to assure that this is universally the case. The recommended requirements are summarized in Figure S.13 in the categories"Person-in-Charge, All Conditions" and "Emergency Response Personnel" both fire fighting and abandonment and damage control supervision requirements. Since the fire fighting and abandonment requirements apply to all except entry level personnel, they will be discussed later under a separate heading.

The thrust of the MODU service time requirement, during which the individual must have served as a Tool Pusher and/or in some other onboard supervisory capacity, is to assure that the Tool Pusher has the broad-based experience in offshore drilling operations to genuinely understand and provide leadership in all on-station functions. The deficiencies of time requirements have been discussed. However, they assure that personnel at least have the opportunity to become knowledgeable, and it appears to be entirely reasonable to believe that personnel could not be promoted to and remain in a supervisory position on a MODU without demonstrated competency.

A provision is made for service in land drilling as well. In that case, there is an additional requirement for the drilling company to provide the individual with orientation to offshore operations. The details of such orientation can best be worked out by the industry. Orientation is presently provided for drilling personnel with no offshore experience. The task analysis data covering the nondrilling functional areas (in Volumes II and III of this report) could be used to check the completeness of the orientation procedures presently used. The task data delineating drilling activities unique to MODUs that drill in the floating condition could be used in the same way as applicable to the particular MODUs of the drilling companies.

Wherever the individual has gained his industrial experience, it is recommended that he be required to be involved in at least two off-station and two on-station move evolutions, where the "evolution" is defined to include positioning, ballasting, and anchor handling as required, depending on MODU type, to get into position for engagement of drilling equipment or to move off location. This requirement is intended to ensure that the Tool Pusher is familiar with the MODU's marine-related equipment and systems and with the critical operations of moving on or off location, so that, even if the Tool Pusher is not the person immediately directing the operations (i.e., a specialist or specialist team is used), he will understand the work being done and be able to generally monitor and facilitate that work effectively as person in charge of the MODU. To achieve that result it is believed to be essential for the experience to be on the <u>particular type</u> of MODU on which the Tool Pusher will serve. As indicated in the MODU descriptions in this volume, and in the differentiation of task data for the functions of positioning and navigation, there are certain highly significant differences in the equipment and operations performed in moving MODUs of different types.

The requirements related to damage control supervision in Figure S.13 are, along with the move experience, designed to close a potential gap in marine-related training for the function of person-in-charge, all conditions. As shown in the preceding Table S.10, the Tool Pusher typically has broad oversight responsibility for assuring the marine integrity of the MODU at least on station. Training is recommended in the areas of stability and seakeeping characteristics, under emergency and potential emergency conditions, as well as training in procedures for maintenance of stability (including damaged stability). It is recommended that this training, like the move experience, be specific to the <u>particular type</u> of MODU to which the individual will be assigned.

<u>Qualifications for the Function of Directing MODU Handling During Moves</u>

As previously stated, there appear to be no set requirements (at least not industry wide) for the various specialists who may have directing roles in MODU moves, except when the MODU is self-propelled. It is believed that requirements should be established to include both minimum experience and demonstration of marine knowledge.

One additional requirement is recommended for the self-propelled MODU case on the basis of the task analysis. Although the person directing underway operations and, frequently, positioning of a self-propelled MODU must

hold an unlimited Master's license issued by the U.S. Coast Guard, the qualification requirements for that license do not ensure that the individual will have experience with MODUs. Experience on merchant vessels is believed to be sufficient preparation for navigation and positioning of drill ships and floating drill barges. However, the configurations and systems of semisubmersible and jackup drilling units, especially the latter, are different enough that experience with them prior to assuming a directing role appears to be warranted. (The same is true of submersibles. They are included in the recommended requirement as presented in Figure S.13 for the sake of completeness, but there is no self-propelled submersible in existence.)

Thus it is recommended that any unlimited Master to be assigned to a jackup or semisubmersible MODU should be required to be onboard for a minimum of three moves on a MODU of the particular type before directing MODU handling. It is further recommended that before the Master directs a self-propelled move, he must have participated in at least one self-propelled move on a MODU of the same type. Likewise, before he directs a towed/towed-propulsion-assist move he must have participated in at least one such move of a MODU of the same type. A comparison of the task analysis data (Volume II) for underway operations on the different types of MODU will demonstrate the reasons for these requirements.

For drill ships and drill barges, again it is believed that no special requirement is necessary. The fact that the Master holds an unlimited license would seem to provide sufficient assurance given that the drilling company attests to his capabilities to handle either type of MODU.

Only the towed/towed-propulsion-assist mode of underway operations is applicable to the move specialists (i.e., Rig Mover or equivalent) who may have directing roles in move functions. The requirements recommended for them are more stringent than those stated above for the Master. Because the move specialists do not necessarily have the broad maritime background of the unlimited Master, it is recommended that their experience prerequisites be specific to the MODU type without exception.

It is also recommended that they be required to demonstrate knowledge of the marine environment and seamanship. This might be done by oral or written examination or by satisfactory completion of training. Again the task analysis data covering move functions by type could be used in the development of training guidelines.

The requirements for move specialists also stipulate that the prerequisite experience shall include the entire move evolution. The reason for that is that the move specialists are the personnel who direct the operations of getting into position for engagement or disengagement of drilling equipment and of moving off location, except on drill ships, where the unlimited Master directs these operations. (Also, if there is an unlimited Master on a floating drill barge he may direct the positioning operations.)

A provision has also been made for regular MODU personnel (e.g., Tool Pusher, Barge Engineer) to qualify for directing MODU handling on moves. The requirements for these personnel are the same as for the move specialists except

that their experience must be specific to the MODU class. This is because their other responsibilities do not permit them to gain familiarity with differences in design that occur between MODUs of the same type. The reasoning behind this provision is that onboard personnel gain in-depth knowledge of a particular MODU and should be able to take a directing role in moves of that MODU or others like it, given the opportunity to gain move experience and to develop suitable maritime knowledge.

Emergency Response Recommendations

Recommendations concerning fire fighting and abandonment apply to all personnel. They are based on an apparent lack of opportunity for realistic, hands-on training in these areas. Because many MODU personnel have had no seagoing experience, training in abandonment by means of lifesaving appliances seems especially important.

Hands-on training is defined as operation of the actual systems and equipment under conditions that approximate emergency conditions as closely as possible. Special facilities would be needed for this type of training. IADC coordination and leadership in getting such facilities established would appear to be appropriate. Expanded use of existing fire fighting schools might be explored. (Entry-level personnel are excluded from this recommendation because turnover rates make their involvement impractical.)

The recommendation of training related to damage control has been explained as it applies to the Tool Pusher. The requirements proposed in this area (as shown in Figure S.13) also would apply to the Rig Maintenance Supervisor and Barge Engineer (or equivalent titles). The intent is to assure that the personnel who have direct supervisory responsibility for stability, hull damage, etc., have an understanding of the hazards of the marine environment as they may affect the stability and seakeeping characteristics of a MODU and its integrity on station. Thus specific training in these areas is recommended for all of the cognizant personnel, under the heading of "Damage Control." This is a precaution since regular MODU personnel may not have marine backgrounds and their normal work experiences onboard may not provide adequate opportunities for on-the-job training in the maintenance of stability under emergency or potential emergency conditions.

Other Recommendations

All companies should be engaged in developing independent study and on-the-job training aids and in promoting their use by MODU personnel. The training initiatives made by some for overseas as well as domestic operations provide excellent examples. The task analysis data should be useful in rounding out on-the-job training resources. A task-oriented presentation would appear to make the material easier for personnel to assimilate. The use of closed-circuit TV with training videotapes and corresponding programmed instruction manuals would appear to be the best combination. Increased effort to educate supervisory personnel in how to help people learn and to create onboard training opportunities without disrupting operations appears to be warranted.

Each MODU should have a marine operations and safety manual specific to the design and equipment of that particular MODU. Such a manual would serve as a training resource; it would assist the Tool Pusher in exercising total responsibility for the safety of the MODU, including move-related operations and preparation for impending bad weather; and it would serve as a reference for specialists who may serve in the role of MODU handler in becoming familiar with the particular characteristics of the MODU.

Further study is needed in two areas:

- Training and experience needs of towing vessel personnel, since they may be responsible for the security of towing arrangements and for navigation underway

- Engineering and human factors problems with the different types of lifesaving appliances in use on MODUs.